„OVIDIUS" UNIVERSITY OF CONSTANŢA
FACULTY OF NATURAL AND AGRICULTURAL SCIENCES
SPECIALTY: ECOLOGY AND ENVIRONMENTAL PROTECTION

Impact of routine and conflict military activities on coastal marine ecosystems, and appropriate measures to reduce / annihilate adverse effects. Case study: accoustic emissions in coastal marine environment, and their effects on representative species

Summary of the Ph.D. Paper

RESEARCH COUNSELOR

Prof. Marian-Traian GOMOIU, Ph.D.

Correspondent member of the Romanian Academy

Ph.D. CANDIDATE

Cpt. cdor. eng. Dinu - Vasile ATODIRESEI

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INTRODUCTION

Military activities have always been associated with destruction ... Future military actions, due to their rapidity, complexity in using means of combat, regardless of the conflict nature (terrorist actions, continuous, or asymmetric war , NCW, i.e. Network Centric Warfare, Geophysical or genetic war, etc..) will influence the environment, ending in hard to estimate and control effects. There are a number of articles, books and publications in international literature dealing unilaterally (single pollutant), or jointly (evaluation of several factors) with the phenomena related to the impact of military activities on the marine environment. However, at present, in our country, there is no research to show the phenomenon as a whole, and to present the causes that lead to the effects observed in similar works worldwide.

In the first part this paper aims at outlining the general framework in which observations and experiments have been performed, and also at the current state of knowledge, at the presentation of the work site (the Southern, i.e. shallow part of the Romanian Black Sea coast), and at establishing the geopolitical components regarding security in the Black Sea, as well as at the theoretical aspects of the potential destructive military activities on the marine ecosystem; it also observes the effect of noise emission on acoustic sensitivity of hydrobionts.

Part two was devoted to analyzing the impact of military activities on coastal marine ecosystems in routine (by theoretical and experimental underwater explosion, explosion at the interface air – water, and acoustic emissions of the sonars) and conflict situations (simulation of the impact of military actions by using simulators), followed by a case study on acoustic emission (as a major disturbance factor) on the marine environment, and their effects on representative species, including pioneering studies in our country in this field by processing the emitted acoustic signals, the induced effects, respectively. Approaching the second part without setting specific objectives couldn't have been done; therefore they follow bellow:

- Study the effects of routine military activities on hydrobionts;
- Influence of noise emissions of species which are representative for the Romanian Black Sea coast;
- Identification of the level of underwater noise in the port of Constanta, and the sounding response of the dolphins (*Tursiops truncatus*);
- Simulation of the impact of military conflict situations using the *Proteus simulator , the Dangerous cargo simulator, and the* TRANSAS *integrate*d simulator for ship steering.

This paper makes a contribution to the need for knowledge in the field, through objective scientific means.i.e. graphical and numerical simulations that can be quickly implemented in military applications and beyond them, with estimated effects on the marine environment, as a solid support for any real activities during combat actions. The firts studies in the field, in Romania, started with new methods for the spectral analysis of underwater noise generated in vessel traffic conditions, with studying the effects of accoustic emissions on certain species under laboratory or natural environment, as well as with the study of the signals emitted by dolphins *(Tursiops truncatus)* in response to accoustic emissions, in the proximity of ports along the Romanian part of the Black Sea Coast.

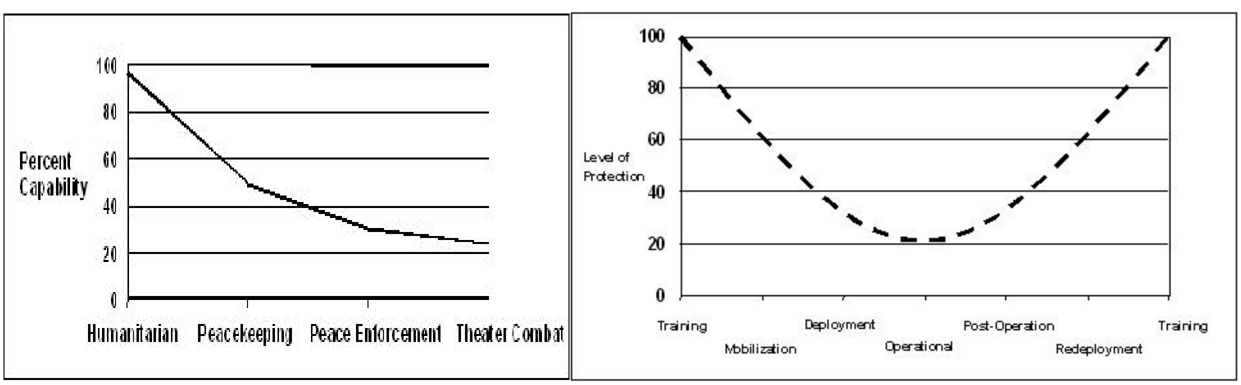
1. THE BLACK SEA – GENERAL CONSIDERATIONS

The first two subchapters present a brief history of research - representative institutions and scientists, as well as research programmes, followed by a physico - geographical and hydrological caracterization of the Black Sea (**Fig. 1. 1**) as an area used for conducting tactical scenarios, observations and measurements for underwater explosions and acoustic emissions.

Fig. 1. 1 - Black Sea - hydro-geographical map (Antipa, 1941)

The third subchapter presents the ecologically and economically representative species of the Romanian Black Sea coast. In the last subchapter, an analysis of the geopolitical situation in the Western Balkans and the Black Sea is made, followed by an evaluation of the potential risks and threats to national security in the Wider Black Sea, including ecological risks, as well.

After noting these risks and threats, the main types of military missions and actions that the Romanian Navy can accomplish are established, taking into account how they are related to the environmental principles (**Fig. 1. 2**); these factors will shape the model for the simulation process of a military conflicting action, and relational diagram - military activities / actions on marine ecosystems (**subcap. 9. 1**)



a **b.**

Fig 1. 2 – Considerations concerning environment protection in relation to: a. Mission type; b. Stages of the mission (according to www.globalsecurity.org)

Major strategic objectives of the coastal marine environment in the context of future maritime strategy can be defined as follows (Chiţac and Atodiresei, 2011):

1. Ensuring uniformity of procedures for identifying, designating, and protecting critical naval infrastructure.
2. Accurate evaluation of the level of vulnerability of critical infrastructure, and measures taken for reventive action, as well as dimininuation o the effects on marine environment.
3. Implemenation of a warning system to notify risk of the environmental factors in advance
4. Development of cooperation at national, regional and international level concerning marine environmental protection, to achieve integrated management of coastal zones, and critical infrastructure of the Black Sea.

2. CONTRIBUTIONS TO KNOWLEDGE DEVELOPMENT OF MILITARY ACTIVITIES WITH EFFECTS ON COASTAL MARINE ECOSYSTEMS

This chapter consistes on two parts that deal with:

2.1 Destructive military potential to coastal areas, and the analysis of main descriptive parameters concerning the use of forces, means of combat and discovery with effects on coastal marine ecosystems, and

2.2 Peacetime military activities with collateral effects on coastal marine ecosystems, as well as the need for military actions simulation with major impact on the environment.
In the first part, it addresses four types of military means to impact on ecosystems:
• underwater combat means having as a damaging effect underwater explosi: marine mine, torpedo, dredging materials, and anti - submarine bomb (Annexes 2.1, 2.6);
• surface combat means producing explosions in the air, or at the interface air/water: hat the effect of producing destructive explosions or air interface air / water: naval artillery instalation , and naval combat missile (Annexes 2.9);
• use of sonars and producing hydro-acoustic emissions: hidrolocation stations and sonar systems (Annexes 2.11);
• means pertaining to communication and discovery system related to the electromagnetic environment: main electronic systems, and the particular system of sensors and integrated transducers aboard a military ships (F-221).

A separate analysis was dedicated to underwater explosion, as all means of combat (be them at surface or underwater), as well as the dredging operations, end (in most cases) in underwater explosion (Annexes 2.7 - 2.8); underwater explosion is characterized by a series of parameters (pressure, impulse, and energy of density flux) with fatal effects, especially on fish and mammals.

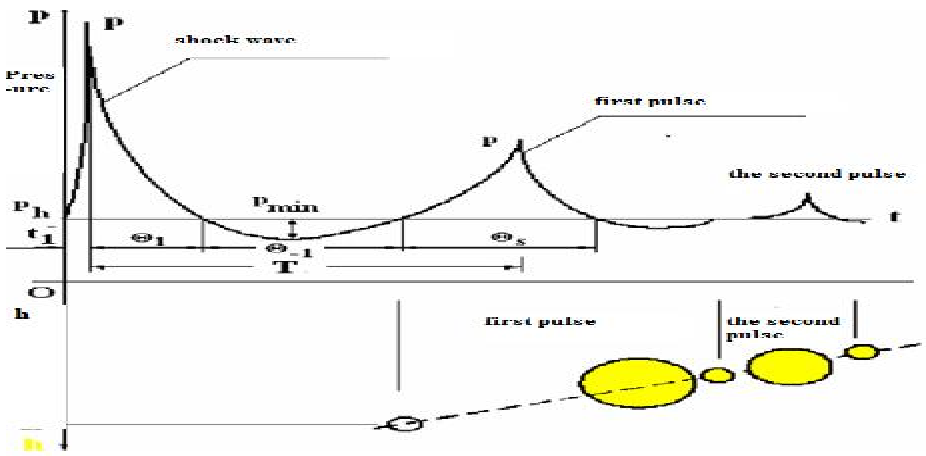


Fig. 2. 1 - Evolution of pressure profile during an underwater explosion (Goga, 2004, Ichimoaei 2006, Toma, 2010)

Side effects on coastal marine ecosystems, resulting from military operational activities that use the above mentioned combat means are considered separately in Chapter 6. The second part of the chapter deals with peacetime military activities based on the critical analysis of the existing literature, taking into account estimated potential effects on marine ecosystems in the coastal north - western part of the Black Sea (**Table 2.1**.)

Table 2.1

Compatibility between different "users" of the coastal marine ecosystem resources, related to military activities

USER	**Wind platform**	**Marine reserves**	**Fishing**	**The sea as a public good**	**Undersea cables**	**Navigation**	**Ports and facilities**	**Coastal agriculture**	**Mine mining**	**Petroleum and natural gas exploitation**	**dredgers factivities**	**Maricultura**	**Tourism**	**Coastal Services Center**	**The protection of the marine environment**	**Protecting coastal reserves**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Military activities																

Legend :

- high degree of incompatibillity
- compatibility limit
- compatible

The chapter concludes by arguing for the necessity of military action simulation with a major impact on the environment as a major requirement to achieve a single, integrated, united and valid action, to support all military operations while reducing / limiting the negative effects on environment (*Development strategy of modeling - simulation field of the Romanian Army, 2003).*

3. SOUND EMISSIONS STUDY IN MARINE ENVIRONMENT AND THEIR EFFECTS ON THE ACCOUSTICAL SENSITIVITY OF SOME HYDROBIONTS

The chapter contains two parts:

1. Description of noise emission sources in the marine environment as a result of current activities, i.e. marine traffic noise, the activities of hydraulic structures and river facilities, oceanographic research equipment including geological core sampling, etc..

2. Sound system in the marine environment and its ecological impact, with:

- presentation of auditory components and mechanisms involved in transmission / reception of sound waves by marine organisms - invertebrates, fish and mammals;
- classification of fish species according to their accoustic sensitivity (Annex 3.1);
- preliminary evaluations of the impact of anthropogenic noise on accoustic sensitivity of fish and mammals.

Special attention was given to studies on the methodology and analysis of fish response to noise emissions; the experimentwas made with fish that was kept in cages in its natural environment for experimental purposes (*Neogobius melanostomus*); possible measurable effects were analysed. The last part deals with the selection of representative species for conducting experiments - mussels (*Mytilus galloprovincialis*) and fish (*Neogobius (Apollonia*) *melanostomus*); currently it seems almost impossible to conduct appropriate experiments on the Black Sea mammals (*Tursiops Tursiops, and Phocena phocena Dephinus delphis*) because of the lack of equipment, and to the absence of specimens kept in captivity.

4. OBJECTIVES

In the elaboration of this paper my work consisted in two phases: 1. analysis of the impact of military activities on coastal marine ecosystems, in routine situations (through theoretical and experimental studies of underwater explosion, explosions at the air-water interface, and sonar accoustic emissions) and in conflicting situations (simualtion of the impact of military actions through the use of simulators), and 2. Study of accoustic emissions study in coastal marine environment, and their effects on a few common species. From the beginning I had in view following specific objectives:

● Study of the effects of routine military activities (underwater explosions, explosions in the air-water interface, hydro – accoustic emissions - on board ships) on hydrobionts (**Ob. 1**);

● Influence of noise emissions on a few type specimen in the Romanian Black Sea coast (**Ob. 2**);

● Identification of underwater noise level in the port of Constanta area, and sound response of the dolphins (*Tursiops truncatus*) (**Ob. 3**);

● Simulation of the impact of military conflicting situations through the use of Proteus, Dangerous Cargo Simulator, and the TRANSAS Integrated Simulator for Ship Steering. (**Ob. 4**).

In order to achieve the intended aims and objectives my activities included:

► measurements, processing of statistical data and of the observations made during military exercises in the study area between 1997-1998 and 2005-2010;

► observation of experimental groups of *Mytilus galloprovincialis* and *Apollonia (Neogobius) melanostomus* in the laboratory and *in situ* which were exposed to various sources of noise produced by vessels and hydrolocation equipment (hydrophones), resulting in installation of *oxidative* stress ;

► modeling - simulation programmes in the field.

The study of accoustic emissions started from the information available at this time internationally; their measurements were made using the latest methods and equipment in the field.

5. RESOURCES AND METHOD

In order to complete the paper, I used a range of equipment and methods appropriate to the stated objectives. Part of the equipment used for *in situ* measurements were obtained as a result of research contracts; I also used the software and simulators belonging to "Mircea cel Batran" Naval Academy.

5.1. The experimental configuration and the proposed method for the theoretical determination of parameters of underwater explosion when combat means are used made in coastal areas (districts) of the North – West Black Sea, in routine situation (training / experimental releases) , in order to to estimate their effects on hydrobionts.

In order to obtain the parametres of underwater explosion in routine situations, and to estimate the effects on the main categories of hydrobionts, we developed and applied the following method:

1. The selection of districts in which various combat means in routine situations are used, made in compliance with the rules of the navy, had in view technico - tactical caracteristics and specific exercises, as seen in the layout 1.250.01 of districts, for application activities, in order to determine the potential effects on coastal marine environment (**Fig. 5. 1,** Annex 5. 1). The general purpose of the established districts, as seen on the map, is as follows:

a_1. Anti-submarine Bomb Releases: Mangalia III; Midia III, Constanța III.

a_2. Anti – submarine torpedo releases, or releases of anti-submarine torpedos against surface ships: Mangalia IV-V.

a_3. Rocket launches and artillery firings: Mangalia II, Constanța II; Midia II.

a_4. Dredging exercises: Mangalia II; Midia II; Constanţa II.

2. Selecting means for fighting specific for each district, taking into consideration their possible use (anti-submarine bombs, torpedoes, marine mines) (**Table 5. 1**)

3. Setting the distances for measuring the explosion parameters, taking into account the explosion site and its production (m), in compliance with the existing regulations;

4. Calculation of the dynamic pressure value (Pd), in the shock wave (daN/cm2 or bar), as related to the distance measured from the production site of the explosion (m), based on the selected formula;

5. The analysis of estimated effects on the main categories of hydrobionts, if different types of combat means are used, based on quantitative and qualitative evaluation of

species and their reporting to the determined values (calculated) of dynamic pressure (Pd) on the shock wave.

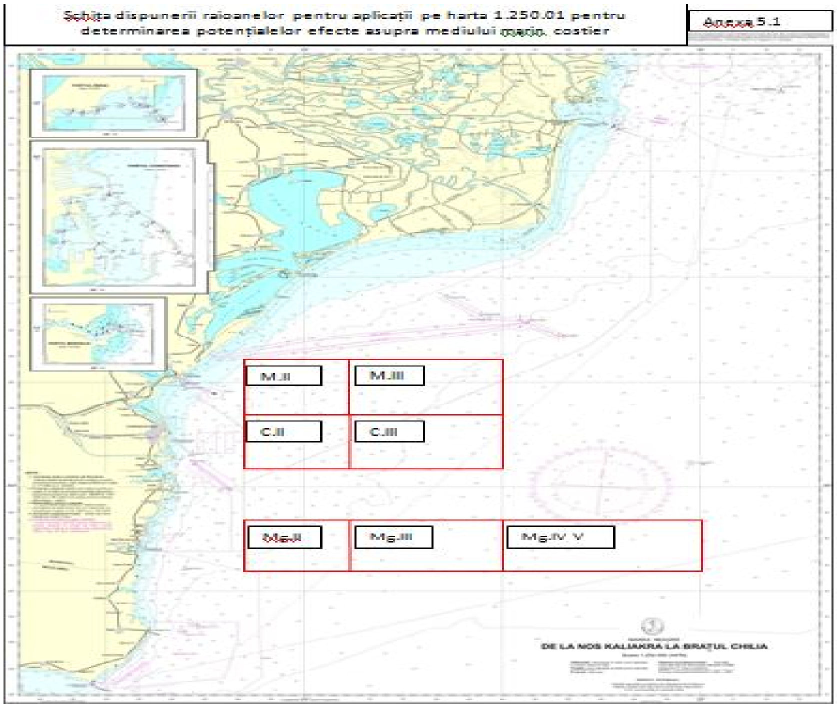


Fig 5. 1 - Layout of districts for applications on the map 1.250.01

Table 5. 1

Selection of underwater combat means on types of districts

Nr crt	Type of district	The selected combat means	Observations-description of combat means
1	District for anti-submarine bomb releases	BR-1200, BR-2500, BR-6000, BAS-66	Technic – tactical, and constructive characteristics in compliance with cub chapter
2	District for torpedoes for anti-submarine torpedoe releases against surface ships or T 53-VA, T53-KE, SET 53, SET 53 M	T 53-VA, T53-KE, SET 53, SET 53 M	
3	3 District for dredging exercises (destruction of mines) MMCA-1, MMA - 2, MAD - 1, MAD - 2	MMCA-1, MMA – 2, MAD – 1, MAD – 2	

Analysis of the effects on hydrobionts was based on the quantitative evaluation of two pelagic species (*Sprattus sprattus and Engraulis enchrasicholus ponticus*) and the reporting to the calculated values of the dynamic pressure (Pd) on the shock wave, in case explosion was produced in two locations (areas), location of differents districts, selecting the number and types of combat means; the releasing scheme is drawn on the occasion of specific applications developed by the navy (AREA I: Location: Constanta district III, and AREA II: Location: Mangalia district III).

Collecting the dead specimens was performed using the "squares" method (wooden rectangular frame) on the water surface for a number of 2 x 10 plots arranged in two rows at a distance of 50 m from the axis of ship to the launching track outside the area, and their "fishing out " , for Area, i.e. by placing the wooden frame on the water for a total of 2 x 10 plots arranged in two rows at a distance of 50 m from the axis of teh major semi axis, outside area II . Subsequently the specimens were measured and assigned to length classes.

5.2 Materials and methods used for experimental research of accoustic emissions on coastal marine environment, generated by marine traffic, and determination of their effects on type speciemns, in the north-western Black Sea.

The quipment used in experiments was obtained under the RoNoMar contract, from Bruel & Kjaer Company (B & K) , and was used to perform measurements of underwater noise. Bruel & Kjaer is a world leader in both instruments and software product, it provides accurate and reliable data concerning noise and vibration measurements, and their analysis (Annex 5.2). The following equipment was used (**Fig. 5. 2**): 3 8106 hydrophones type 2 hydrophones type 8104, type 2713 power amplifier, data acquisition system XI LAN, laptop 14 PULSE software, cables, type 4229 calibrator.

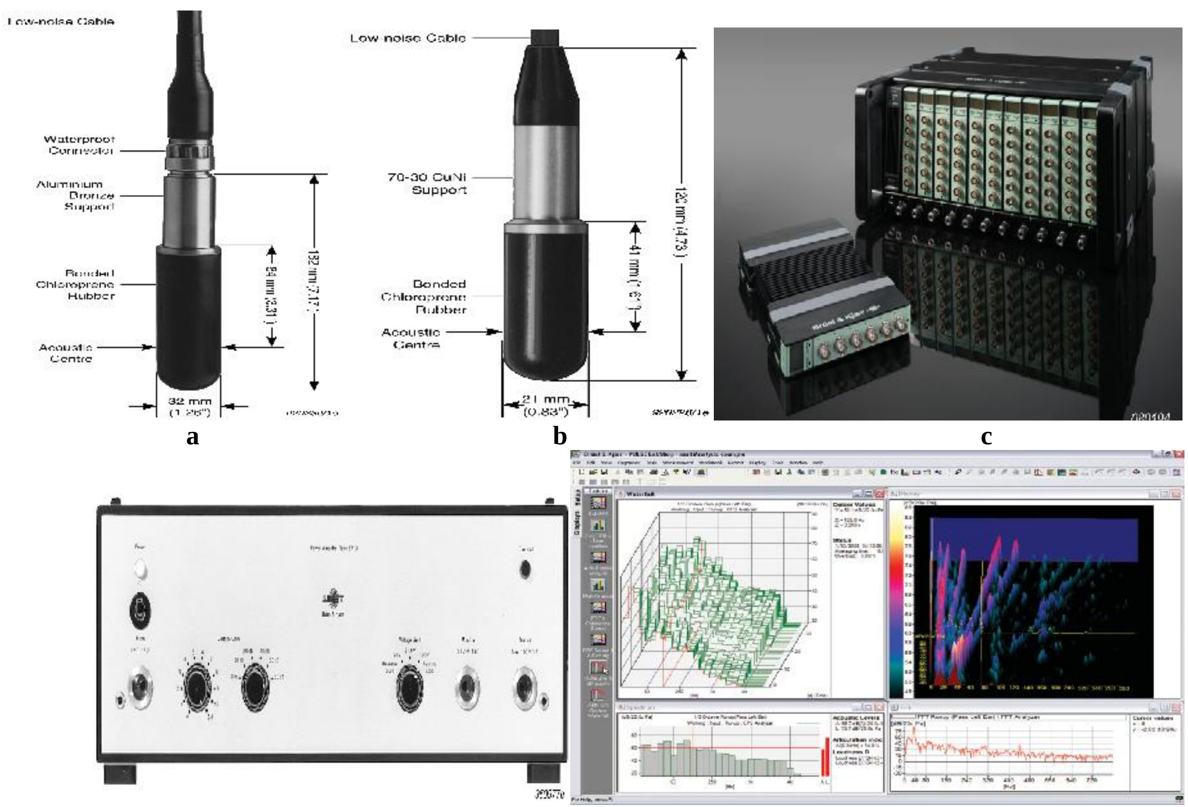


Figure 5. 2 - Equipment used for the experimental research on accoustic emissions in the coastal marine environment: components of a 8106-type hydrophone; b -8104 type hydrophone; LAN-XI data entry syste; d- type 2713power amplifier; e- the screenshot representing the PULSE 14 software from Bruel & Kjær's

Underwater sound measurements were processed and analyzed by the help of the FFT analysis (Fast Fourier Transform) and the Wavelet analysis.

In order to study the influence of vibration (as a source of noise) on the physiological activity of the Black Sea blue mussels (*Mytilus galloprovincialis*, Lamarck, 1819), healthy individuals were collected by scraping mussels off the epybiosis of berth no. 79 located in the south of Constanta Port, less influenced by port operations (**Fig. 5. 3 a and b**). A quantity of 180 l seawater was taken from the same area to fill the experimental ponds / tanks.

A b

Fig. 5. 3 -
Place of sampling mussels (a) by scraping the epybiosis (b)

Vibration in the sample zone was determined (16/03/2010 and 09/04/2010) (**Fig. 5. 4**), as well as the biochemical parameters of collected mussels as eference values for the two series of experiments

A b

Fig. 5. 4 -

Fig. 5. 4 - Determination of vibration values of the marine environment when sampling: a - an overview of the equipment used, b - recording the vibrations on the laptop screen

A total of 80-90 mussels (length class of 35-40 mm and 45-50 mm) were kept in ponds / tanks / aquariums of 40 L, or in 60 L glass ponds (**Fig. 5. 5**), at temperatures ranging from 10-13 ° C, salinity from 14.1 to 14.6, pH = 8.2 to 8.4 IU, food being provided by algal cultures obtained from existing diatoms in seawater enriched by culture sp. *Tetraselmis*. Water oxygen tanks was provided by bubbling air.

For each experimental stage 2 tanks of different dimensions were used: the first, a 30 litre tank, and the latter, a 50 litter one. For all the experiments a witness tank was used for monitoring the mussels evolution in normal conditions (**Fig. 5. 5 b, c**).

a **b** **c**

Fig. 5. 5 - Ponds (aquariums) used in the experiment : a experimental ; b, c witness

The experiment was conducted over a period of 4 weeks, and two repetitions every 2 weeks for each of them. During this period, mussels were "stressed" with acoustic signals of different frequencies. By using the PULSE program at B & K was generated and sent to 7071 V RMS signal through LAN DAQ XI, and the power amplifier type 2713 to type 8104 the two hydrophones. Noise was measured with two hydrophones type 8106, which were connected to the DAQ and then the signals were transmitted to the laptop (**Fig. 5. 6**). Position hydrophones type 8106 in the tanks was about 6-7 cm from the bottom and 8.9 cm from the side

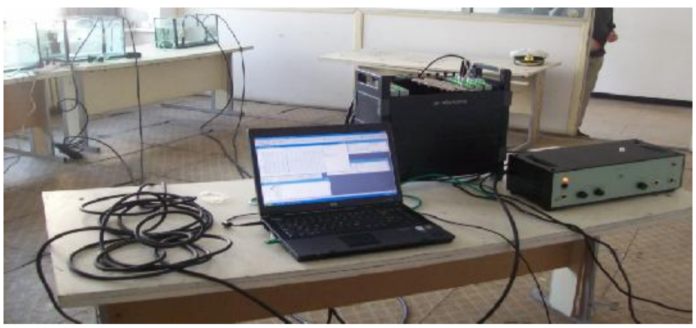


Fig. 5. 6 - Experimental configuration

In the first experiment the emission frequency was 300 Hz signal, while in the second it was 16000 Hz. Signals were generated using the 8104 type hydrophone as transmitters. A second source of noise was the air pump, with a fundamental frequency of 50 Hz. In conclusion, during the experiment there were continuously two sources of noise in the basins.

In order to study the influence of vibration (as a source of noise) on the physiological activity of fish, healthy specimens of the species of fish *Apollonia (Neogobius) melanostomus* (Pallas, 1814) were collected from the rocky bottom of the Southern Romanian Black Sea coast and transported in 100 l barrels with seawater at 16 ° C (**Fig. 5. 7**).

Fig. 5. 7 - Preparing the fish for being transported

The experiment took place around the maritime station (**Fig. 5. 8**), where the ship "Noordkaap" was moored; three experimental cages were carried on board (**Fig. 5. 9**).

Fig. 5. 8 - The site of the experiment(www.joie.ro/2010/07/gara-maritima-constanta/ *)*

Fig. 5. 9 - The « Nordkaap » ship and the cages location
1, 2, 3 –the cages with experimental groups ;   4, 5 –hydrophones; 6 –the source of noise

There were two rypes of fishing net the cages were made of: the first, with the mesh size of 12 mm, was used to build the side walls of a 1 meter cube. The same material was used to make the upper wall, which is a trap door that allows access to the cage. The latter, with a mesh size of 7 mm was used to make the bottom of the cage (to allow the placement of mussels used as food). The walls of the cage were reinforced with 7 mm diameter metal rods (**Fig. 5. 10**).

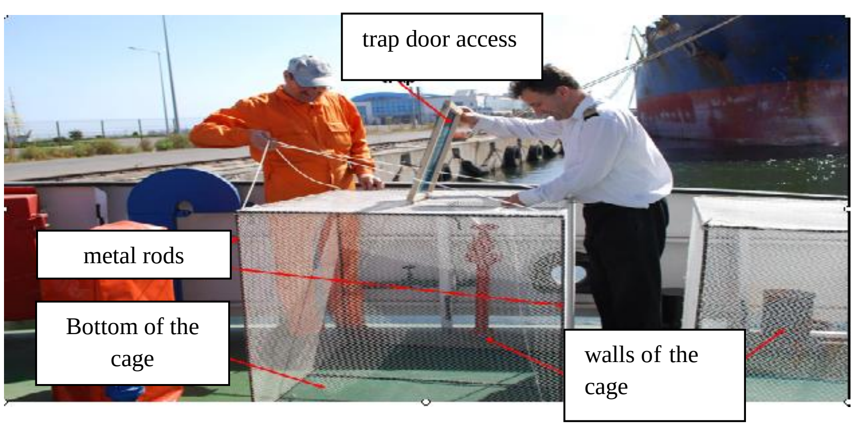


Fig. 5. 10 – Structuer of teh cages

There were 30 fish placed in each cage by the help of a fish landing; the fish was given its favourite food (Bănărescu, 1964): live mussels and chunks of fish meat and beef (**Fig. 5. 11a - c**).

A **b** **c**

Fig. 5. 11 - *Apollonia (Neogobius) melanostomus* in cages: a = colony of mussels placed on the bottom of the cage, b=fish in the the ; c = catching fish with a small mesh (fish landing)

Cages were hooked on in the water column, 12 m deep, one meter above the seabed. A cage containing the control group (GC) was located in the starboard side of another vessel - ("Pompier -8") located approximately 200 m from the noise source.

The three cages containing the experimental groups (GE) with fish were hooked as follows: GE-1, at the bow, GE-2 near the engine room, and GE-3 at the stern (**Figure 5. 9).** The experiment was conducted between 8th -18th October, the sea was calm, and there were no rains or strong winds. The water temperature at surface varied between 15.5 ° C and 18 ° C (average value 16.9 ° C). The equipment used in the experiment consisted in two hydrophones type 8106 (with a general purpose transducer with a frequency range from 7Hz to 80 kHz) (Bruel & Kjaer), a LAN XI for the acquisition system (Bruel & Kjaer), and a laptop with 14 Pulse software installed.

As a source of underwater noise we used a hydro - pneumatic mechanism based on an air compressor (11 bars), with a fundamental frequency of 61-90 Hz, located near the EG-2 at 0.5 m above the top of the cage. This mechanism was used 8 hours a day, in successive steps of one hour emission, two hours break. The hydrophones were placed 1 m away from the cage, on the side. The source of noise had to be placed near the cage no. 2, because the sound is quickly attenuated: the first hydrophone (located near the source) recorded a higher level of noise as compared to the second hydrophone (located at 5-6 m away from the source). The difference between the two hydrophones ranged from 6 dB to 9 dB, depending on the variation of air pressure in teh compressor tank (when air pressure in the tank drops below 6 bars, its engine starts automatically, increasing the pressure value to 11 bars- 11 atmospheres).

After a period of 72 hours from the beginning of the experiment the fish were sacrificed for analysis; their liver tissue was examined in order to state some metabolic parameters of oxidative stress: the superoxide dismutase activity, the catalase, the reduced concentration of glutathione (GSH) and the protein concentration. In determining the metabolic oxidative stress parameters we were helperd by teachers of "Animal Physiology", as follows:

• Superoxide dismutase (SOD) - method based on its ability to inhibit the reduction of tetrazolium salt - Nitro Blue tetrazolium (NBT) with superoxide radicals (Winterbourne, 1979).
• The activity of catalase (CAT) - kinetic method based on the decomposition of hydrogen peroxide radicals existing in the reaction medium, as a result of catalase activity, using a

spectrophotometer at 240 nm and 25 ° C, dt = 60 seconds (Beers and Sizer , 1952).
• Reduced glutathione (GSH) - classical colorimetric method based on DTNB reaction in the presence of GSH in the environment using a spectrophotometer at 412 nm (Beutler, 1975).
• Malonildialdeide (MDA) - conventional colorimetric method described by Drapper and Hadley, 1990 (Bircan et al., 2008).

All of the reagents used for the completion of these experiments were purchased from Sigma-Aldrich (Steinheim, Germany). The data were statistically interpreted using statistical analysis software Origin Pro75. The difference is considered statistically significant when $p \leq 0.05$.

5.3. Experimental conditions for measuring background noise generated by marine traffic at the entrance in the port of Constanta - implications / effects of noise on noise emissions of dolphins in the area

The measurements of the background noise, and acoustic emissions generated by vessels were made in the vicinity of the red port entrance lighthouse, in the port of Constanta during May-June 2010 (between May 8th and June 7th). Each study shows the noise caused by ship traffic at that time. During measurements the hydro – meterological conditions showed calm sea, the air temperature was 20-23 ° C, teh water temperature 16-17 ° C, and there were no rain, or any other weather phenomena to generate noise.

Measurements were made at two points, on May 8th (point 1) and May 24th (point 1 and 2) (**Fig. 5. 12**), in order to identify the main noise sources existing at the entry in Constanta Port , background noise and their implications / effects o the sounds emitted by groups of dolphins in the port of Constanta entrance.

The information about the groups of dolphins was provided by the border police, during their interventions at sea; this helped us correlate measurements made at the enrrance zone with the Naval Academy boat (cutter) heading to the locations where dolphins were observed, and registration of the sounds emitted by them ,for further processing.

Fig 5. 12 - North Constanta port entrance (photo) with measurements points considered (1 and 2)

Measurements were made under the following conditions:
● on May 8th , 10:45: calm sea, air temperature T - 23 °, water temperature 14 ° C, two hydrophone (type 8106) were placed at 2 to 2.5 m depth, 5 maway from the peer and 2 , 5 m apart from each other;
● on May 24th , 06:45: calm sea, T - 20 ° C air, 15 ° C, a hydrophone (type 8104), located 3 m deep and 3m away from the quay;

● for dolphins, on May 24th , 2010, from 9:00 to 11:00: with a vessel traffic separation zone, 2.5 km away from port entrance (**Fig. 5. 13**); 25 m water depth at the anchoring point; 5 dolphins (*Tursiops truncatus*), adults and juveniles; water temperature T, 16 ° C , the sea - 2 degrees Beaufort.

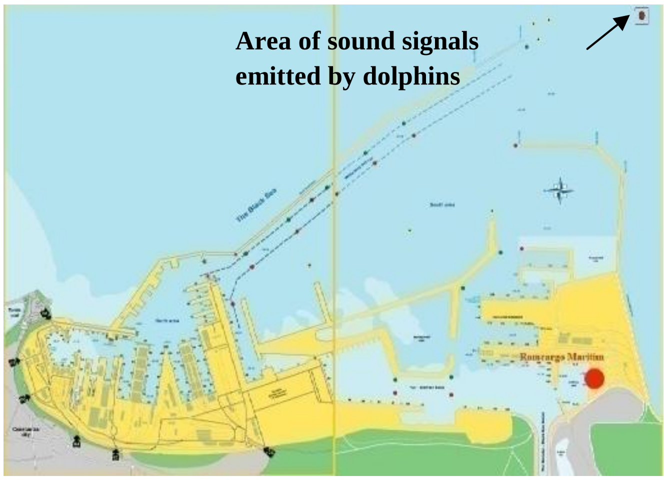


Fig. 5. 13 - Registration area of sound signals emitted by dolphins, located at a distance of 1.5 miles from the port – red point (top right)

The equipment used in the experiments was provided by Bruel & Kjær: 5 hydrophones type 8106 and 8104, LAN XI data acquisition system, laptop with PULSE 14 software, 3 X 100 m cable, 4229 calibrator (**Fig. 5. 14**). Hydrophones were calibrated with an incorporated preamplifier, so as to be connected directly to the LAN DAQ-XI system, Bruel & Kjaer type 4229 calibrator, connected to the 9727 diagnostic system.

Fig. 5. 14 - Equipment used to measure background noise, acoustic emissions of ships, and dolphins' sounds

Underwater sound measurements were processed and analyzed by FFT analysis (Fast Fourier Transform) and Wavelet analysis. For the analysis of sounds emitted by dolphins we also used the Fourier transform for short periods (Short-Time Fourier Transform STFT) or Fast Fourier Transform (spectrogram).

5.4. Setting computer means for developing the general model for simulation of the military actions impact

To simulate the impact of military actions it was intended to created a model of a major pollution process generated by conflicting situations (the pollut model process can be used successfully in routine actions, was well) in the northwestern Black Sea. The following simulators belonging to the "Mircea cel Batran "Naval Academy were used:

- Proteus tactical simulator with all software supplied and installed by the manufacturer (Annex 5. 4);
- Simulator for dangerous cargo – with the spatial-temporal simulation software for marine pollution incidents GNOME (Annex 5. 5);
- Integrated System SIMIN for development and presentation of hydro-meteorological forecasts in the Maritime Hydrographic Directorate;
- "Navi-Trainer Professional 5000" Integrated Simulator for Ship Steering with its ADIOS-2 software for predicting pollution with hydrocarbons (Annex 5. 6).

The novelty of the model used for military actions affecting the marine environment, and intervention to limit these effects lies in its configuration choice (multiple simulators and software that initially worked independently without being connected) and its use in military situations (and the naval accidents) specific to the Naval Forces, whose purpose is to provide the theoretical possibility of estimating the quantities of liquid pollutants (all types of hydrocarbons), as well as practical solutions to intervene in limiting their effects. Unlike dry environment, the environment in which the pollutant is spilled is a liquid one (marine environment), therefore the use of modeling and of simulators aimed strictly at this environment.

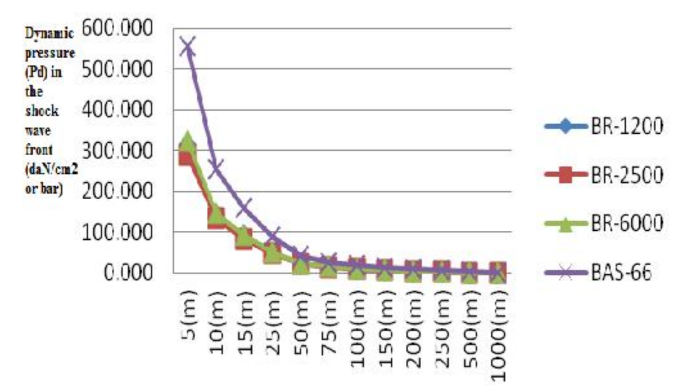
6. STUDY ON THE EFFECTS OF ROUTINE MILITARY ACTIVITIES ON HYDROBIONTS

This chapter deals with the first of the four objectives of the thesis, focusing on the following major directions:

A. The estimated effects induced by underwater combat means based on reports and measurements made on hydrobionts in the NW Black Sea

Considering the current state of knowledge of the effects of the main parametres of the underwater explosion on the species we determined the **first stage**, i.e. the theoretical values of underwater explosions related to underwater combat means used in coastal areas (**Fig. 6. 1**), based on the calculus relation established, and different of means of combat selected according to the method; thus, we obtained the theoretical values for dynamic pressure (Pd) in the shock wave (daN/cm2 or bars) in relation to the distance measured from the production site of the explosion (m) with different types of weapons (Annex 6. 1).

A few conditions must be taken into consideration when establishing the intervals for measuring the pressure of the scock wave front: the amount and nature of explosives used; intended effects on the target species (death, injury, safety threshold, etc.); characteristics of the district . Ranges proposed for theoretical calculations, as well as for the *in situ* experimental validation, according to the model proposed in Chapter material and method are as follow: 5 (m), 10 (m), 15 (m), 25 (m), 50 (m), 75 (m), 100 (m), 150 (m), 200 (m), 250 (m), 500 (m), 1000 (m).



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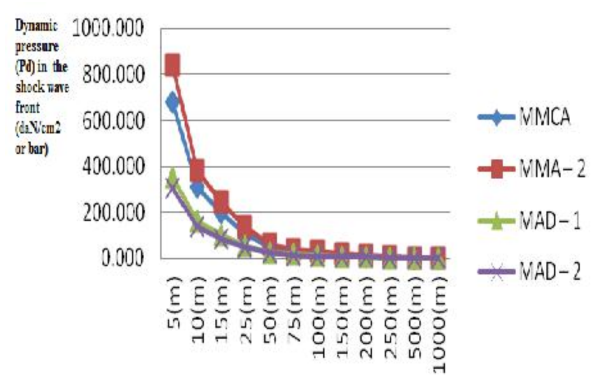

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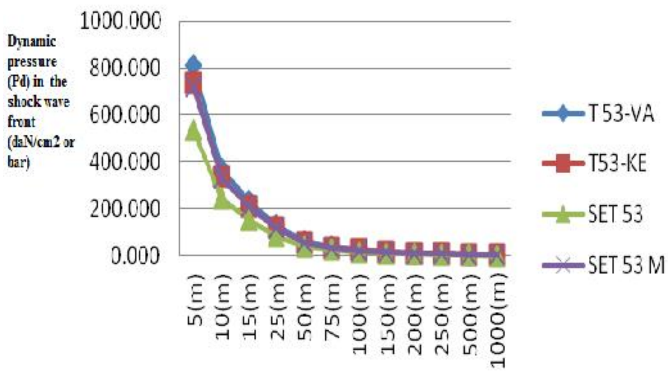


c

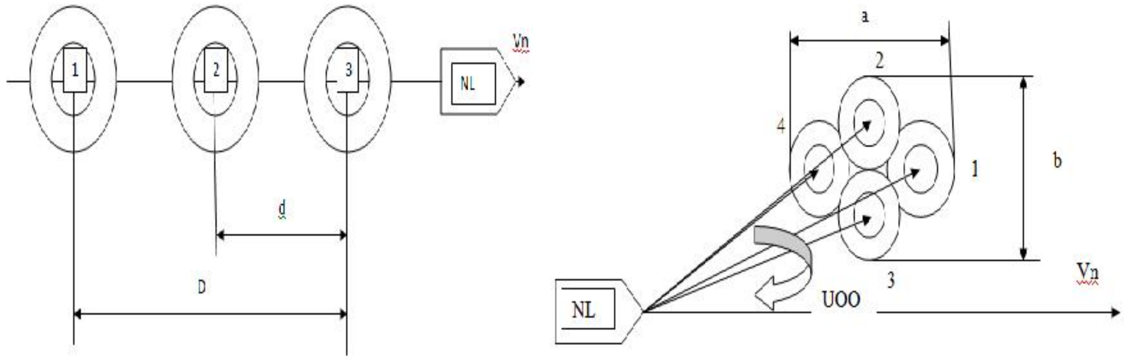
Fig. 6. 1 – Value of dynamic pressure (Pd) in the shock wave front (daN/cm2 or bar) compared to the measured distance (m) in relation to the place of explosion, considering types of: a - anti-submarine bombs, b - marine mine, c - torpedoes.

The need to calculate / measure these parameters was a prerequisite for the evaluation of the effects found in experiments conducted in the **second stage** referring to the two pelagic species of fish - *Sprattus sprattus* and *Engraulis enchrasicholus ponticus.*

As an officer responsible with underwater combat arms, according to the schemes of arrangement of underwater explosions (**Fig. 6. 2**), in areas (districts) for military applications (see location in subchapter 5.1 and Annex 5. 1), we first had in view specific mission objectives (searching, discovery, attack and "destroying enemy submarines"); therefore some classified data (the exact period, the number of vessels involved, features of military launching installations, tactical and technical elements, images / photos, etc..) have a restrictive character in the presentation.

Sampling of the pelagial type specimens was taken starting with the midline of the classic bombings explosion (**Fig. 6. 2a** and the semi major axis of the ellipse spread in reactive bombings case **Fig. 6. 2b**).

According to O 'Keefe's (1984) relation, some distances were estimated, i.e. the distance corresponding to a threshold of 10% mortality (**Table 6. 1**, Annex 6. 2), the distances for which the pressure of the shock wave front will be extracted (**Table 6. 2**) based on interpolation calculations in Annex 6. 1.



a **b**

Fig. 6. 2 - general release diagrams:

a – for ZONE I, where: NL-ship releasing the bomb, Vn- the ship's speed during bomb release- Nd -18.3; d - distance between bombs (50-60 m: tactical considerations); D - length of release midline (200 m); 1,2,3 – BAS - 66 bombs
b - for ZONE II, where: NL –ship releasing the bomb; Vn – the ship's speed during bomb release - Nd -18; a major axis of the ellipse bomb spread (80 -100 m, from tactical reasons) ; UOO - horizontal sighting angle in relation to the ship's heading; , 1,2,3,4 - BR 6000 type reactive bombs

Table 6.1

Maximum horizontal calculated distances (Hmax) according to O 'Keefe's relation (1984) corresponding to a threshold of 10% mortality for pelagic species *Sprattus sprattus* and *Engraulis enchrasicholus ponticus* in zones I and II subject to the underwater explosions

Species of fish	Expe-rimental zones	Type of bombs	Mass of explosive (Kg)	Deep (m) for underwater explosions	Mass of fish (gr.)	Value of coef. k inter-polati-on	Value of coef. a inter-polati-on	H_{max} (m)
Sprattus sprattus	I	BAS-66	140	50	9-14	453	0,26	610
	II	BR 6000	33,04	55	9-14	463	0,26	428
Engraulis enchrasi-cholus ponticus	I	BAS-66	140	50	8-10	453	0,26	610
	II	BR 6000	33,04	55	8-10	463	0,26	428

Table 6.2

Estimated values of of pressure in the shock wave front corresponding to a threshold of 10% mortality for pelagic species *Sprattus sprattus* and *Engraulis enchrasicholus ponticus* in zones I and II subject to the underwater explosions

Estimated values of pressure in the shock wave front		
Type of submarine bomb	**$H_{max\ for\ a\ mortality\ of\ 10\%}$**	**Threshhold for a mortality of 10%**
	m	**KPa**
BR-6000	**428**	**211**
BAS-1	**610**	**244**

Validation of theoretically estimated values was performed based on the set of samples (10 samples) for the two samples (strings) at distances of 50 m for each experimental area. Distances between samples took into considered the correlations between the pressure in the shock wave front, specific for each bomb, and highlighting the expected mortality (**Fig. 6. 3**) Quantitative evaluation results of the two pelagic species (*Sprattus sprattus and Engraulis enchrasicholus ponticus*) for the two areas that underwent underwater explosions are presented in Appendix 6. 3. Subsequently, data were processed statistically using the common methods: calculation of the arithmetic mean, and of corresponding standard errors, check of the means based on the Chauvenet criterion; individual aberrant values were removed from the final calculation of means; the calculation of Student's test "t" (Senedecor and COHRE, 1980) was performed to determine the significance of the difference between the averages compared; the difference was considered significant to the threshold of significance (p) less than 0.05.

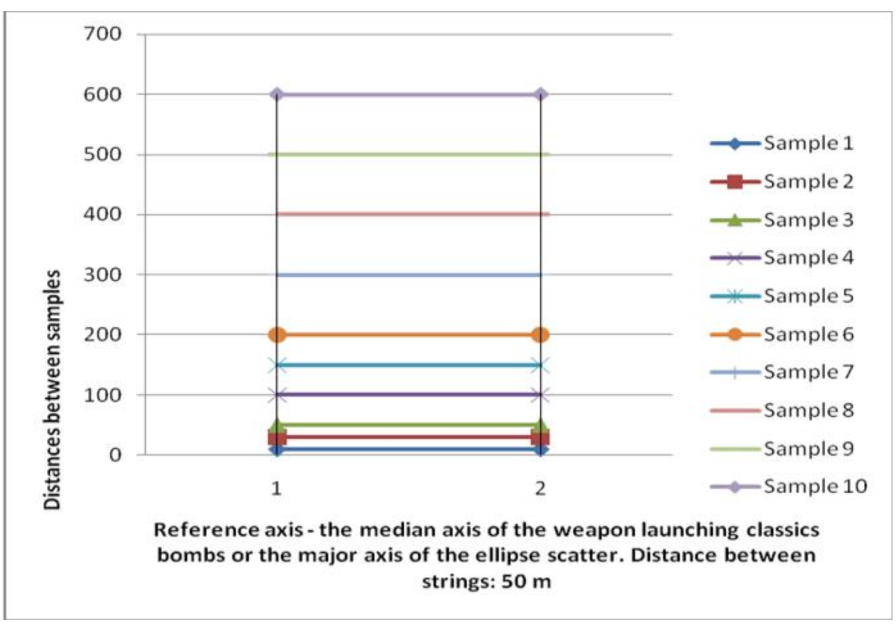


Fig. 6. 3 - The general scheme of sampling for pelagic species *Sprattus sprattus* and *Engraulis enchrasicholus ponticus* in zones I and II subject to underwater explosions.

Statistical processing results obtained for the 2 pelagic fish species (**Table 6. 3, Table 6. 4**) have shown that there were no significant differences between the two sets of measurements taken at distances of 50 m in width in the 2 areas subject to experiment.

Table 6. 3

The mean values obtained for species *Sprattus sprattus* in the two areas subject to underwater explosions

Species / Experimental zone	Sampling number	Indexes	Dimension classes			
			< 8 cm	**8-10 cm**	**10-12 cm**	**>12 cm**
Sprattus sprattus **Experimental zone** 1	**Sampling** I	X ± ES	0,60 ± 0,51	0,8 ± 0,29	0,40 ± 0,16	0,20 ± 0,13
		n	10	10	10	10
	Sampling II (50 m distance)	X ± ES	0,90 ± 0,56	1,00 ± 0,29	0,40 ± 0,16	0,30 ± 0,15
		n	10	10	10	10
		t	1,23	0,48	0,00	0,49
		p ≤	**0,23/NS**	**0,63/NS**	**1,00/NS**	**0,62/NS**
		± M%	***+ 50,00***	***+25,00***	***= 1,00***	***+ 50,00***
Sprattus sprattus **Experimental zone** 2	**Sampling** I	X ± ES	0,50 ± 0,21	0,10 ± 0,10	0,10 ± 0,10	0,00 ± 0,00
		n	10	10	10	10
	Sampling II (50 m distance)	X ± ES	0,60 ± 0,26	0,20 ± 0,13	0,10 ± 0,10	0,00 ± 0,00
		n	10	10	10	10
		t	0,28	0,60	0,00	0,00
		p ≤	**0,77/NS**	**0,55/NS**	**1,00/NS**	**0,00/NS**
		± M%	***+ 20,00***	***+ 100,00***	***= 1,00***	***= 1,00***

Table 6.4

Average values for *Engraulis enchrasicholus ponticus* for the two zones with underwater explosions

Species / Experimental zone	Sampling number	Indexes	Dimension classes			
			< 8 cm	**8-10 cm**	**10-12 cm**	**>12 cm**
Engraulis enchrasicholus ponticus **Experimental zone** 1	**Sampling** I	X ± ES	0,40 ± 0,22	0,00 ± 0,00	0,10 ± 0,10	0,20 ± 0,20
		n	10	10	10	10
	Sampling II (50 m distance)	X ± ES	0,50 ± 0,22	0,10 ± 0,10	0,20 ± 0,20	0,10 ± 0,10
		n	10	10	10	10
		t	0,31	0,00	0,40	0,44
		p ≤	**0,75/NS**	**0,00/NS**	**0,66/NS**	**0,66/NS**
		± M%	***+ 25,00***	***+ 0,00***	***+ 100,00***	***- 50,00***
Engraulis enchrasicholus ponticus	**Sampling** I	X ± ES	1,11 ± 0,37	0,10 ± 0,10	0,30 ± 0,15	0,60 ± 0,33
		n	10	10	10	10
	Sampling II	X ± ES	1,40 ± 0,56	0,10 ± 0,10	0,40 ± 0,16	0,70 ± 0,39

Experimental zone 2	(50 m distance)	n	10	10	10	10
		t	0,44	0,00	0,44	0,19
		p ≤	**0,66/NS**	**1,00/NS**	**0,66/NS**	**0,85/NS**
		± M%	***+ 26,12***	***= 1,00***	***+ 33,33***	***+ 16,66***

NOTE: "X ± SE", the arithmetic mean and standard error,"n" - number of individual samples that resulted in the arithmeric mean in the end, "t" value of Student's test "t" , "p" – significance based on the value of "t" (the change was considered statistically significant for a value of "p" ≤ 0.05), "± M%" - the percentage difference between group under expetiment and control group in question, "NS" - statistically insignificant change

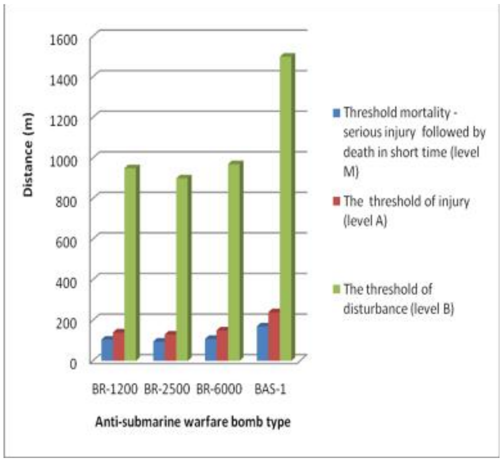
Analyzing the data we see that theoretical results estimated for lethal effects due to underwater explosion on the two pelagic fish species have been confirmed *in situ* as well, resulting in the following conclusions:

- for BR-6000-submarineunderwater bomb explosions, no mortality was recorded among species at distances over 500 m (1 sample of *Engraulis enchrasicholus ponticus* at 400 m) confirming the 10% mortality threshold for lethal distance of 428m at a pressure in shock wave front of 211 KPa;
- in BAS-66 anti-submarine bomb explosion mortality recorded among both species at distances greater than 500 m, confirming the 10% mortality threshold for a lethal distance of 610 m at a pressure on teh shock wave front of 244 KPa;
- mortality at distances greater than 400 m was derected mainly for juveniles (less mass), especially for es *Sprattus sprattus*, thus confirming Young's affirmations (1991) who asserts that juveniles are more vulnerable than adult specimens;
- the number of dead specimens is highly dependent on the initial spatial location of the shoal of fish (mostly in pelagic species) , how far it is from the centre of the explosion, so that an accurate estimate of the total number of dead specimens, of global biomass can be achieved only after a study of the qualitative and quantitative composition of the experimental area;
- the analysis of critical periods in terms of species vulnerability,for those periods of year reported depth of the district, show that producing explosions in teh period April-June in the 60 m isobath, would have maximum effect on fish populations, since in this period migration for breeding and food occur .

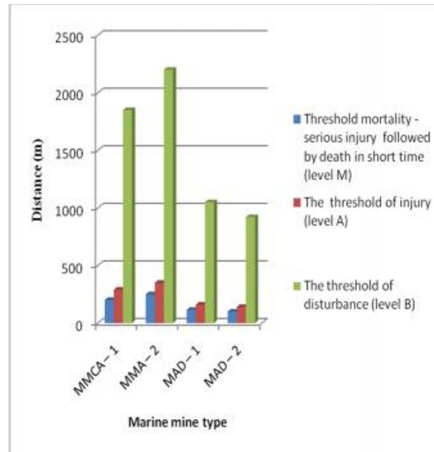
<u>The third stage</u> consisted of estimating the effects of underwater explosions when various means of under water devices were used on marine mammals in the coastal area of northwestern Black Sea for determining the values of distances calculated to determine the threshold values of impact levels, according to literature in the field (Annex 6.4, Annex 6.5); the following results were obtained:

• The values obtained are within the ranges specified for the threshold of developing impact levels confirmed in international literature (MMPA, Parvin et al., 2007);
• The most important impact level on the three species of dolphins (*Phocena phocena, Dephinus delphis and Tursiops Tursiops*) will occur when MMA-2 mine, and T 53-VA torpedo will be used; mortality or injury thresholds appear at distances of 240-250 (m) or 335 to 350 (m); mammals are disturbed if the two means of combat producing explosions will act at distances of 2200 (m) **(Fig. 6. 4);**

The lowest impact is expected to be met when using reactive bombs (BR-1200, BR-2500 and – BR 6000 , depending directly on the amount and nature of explosives.



a



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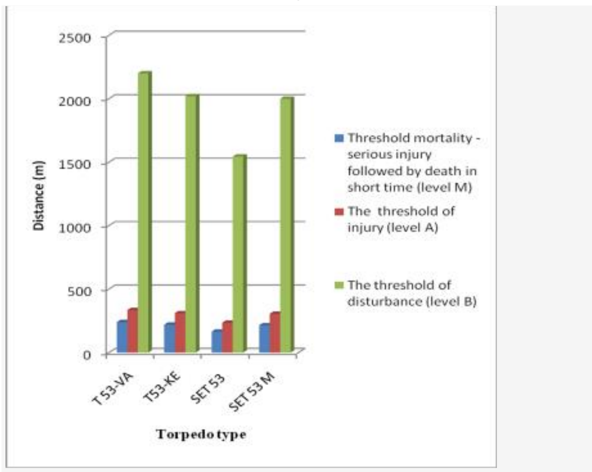


c

Fig. 6. 4 - Estimating the effects of underwater explosions on marine mammals when using: a – anti-submarine bombs; b - sea mines; c- torpedoes

The values were calculated for the case when only one single explosive is used (a single means of combat). In reality when military applications take place more than one explosive is used (especially for reactive bombs), so that distances calculated for threshold levels of impact can "shift" with the successive distances between successive explosions, to which the distance calculated in tables is added .

In the **fourth stage**, were presented the expected effects of underwater explosion on species of invertebrates in the coastal northwestern Black Sea depending on the types of comabt means used; we can conclude that the major effects on marine invertebrates may occur when using anti-submarine bombs and marine mines.

If detonation takes place (mines or MAD MAD-1-2), on the north coast sandy bottoms at depths between 0.5 - 20.0 (m) (**Fig. 6.11**) the following will be affected: the biocenoses of *Lentidium mediterraneum, or associated* species that have a significant biomass, i.e. species of endopsamic shellfish (*Cerastoderma edule,Chione Galina),* or epipsamic bodies : segmented worms (*Neanthes succinate*), snails (*Hinia reticulata, Cyclope shallow-water)* or crabs (*Liocarcinus holsatus*), and newly introduced species of shellfish: *Mya arenaria and Scapharca inaequivalvis*.

Fig. 6.5 – explosion of am anti –assault mine in the coastal shallow waters (0-5m). Photo: The ANMB archive

If detonation occurred in the southern Romanian Black Sea coast, on the hard, rocky bottom, the most affected biocoenoses would be the stone mussels - *Mytilus galoprovincialis*. In macrozoobenthos they will undergo dislocation of the sublayer around some sessile species (*Actin equina, and Balanus improvisus Mytilaster lineatus*) and vagile species: segmented worms (*Hediste diversicolor*), snails and crustaceans.

B. The main expected effects on marine ecosystems in the coastal northwestern Black Sea induced by the use of surface combat means based on existing reports and measurements

Studies undertaken in this field aimed at estimating the effects on coastal marine ecosystems in the NW Black Sea based on observations of 2005-2010 period, and their reporting to the similar results in today's literature in the field, estimating that the effects of artillery firing, and infantry weapons will have a more limited impact on coastal marine ecosystems in the NW Black Sea as compared to findings of present day literarure. Missile used against air targets would have a significant impact on the marine environment,if they hit the sea surface after the race, causing shock waves that could kill or cause serious damage to populations of fish or mammals. Explosive warheads used in air-air missile exercises, cause air explosion, disintegration, followed by the fall in the sea

The main district used for naval missile launches between 2005-2010, was Cape Midia - Năvodari ground (**Fig. 6.6**).

Fig. 6.6 – The exercise " Vector 2010", rocket release-Capul Midia. Source: www.navy.ro

Up to the present date, there was no mortality / injury of the specimens of fish and mammals in this area reported, because the rockets were equipped with inert head, so we can see that the exercises with missile launches would not result in adverse effects to the biota in the region.

C. Effects of hydro-acoustic emissions from military ships on the marine environment in general

In the study of the hydro – acoustic emissions , there is a review of the literature in this field focused on the effects of sonar emissions of hydrobionts on three categories of frequency (low frequency <1 kHz ,medium frequency (1 kHz - 10 kHz), and high frequency> 10 kHz), and also of the the general case of high intensity sonar, concluding that there is a lack of information based on experiments on the effects of exposure to sonar sounds of the vast majority of fish and invertebrates, while the impact of anthropic noise on marine mammals has been extensively studied . Also, it appears that the sources of noise and emissions of sound underwater waves, the military sonars (the low frequency sonar <1 kHz) are responsible for strong negative effects on the marine organisms, especially on species of mammals, as fish swimming bladder is not large enough to resonate in the low frequency band, except for some species (*Thunnus*).

7. INFLUENCE OF NOISE EMISSIONS ON SOME REPRESENTATIVE SPECIES OF THE ROMANIAN BLACK SEA COAST - EXPOSURE OF *MYTILUS GALLOPROVINCIALIS* AND *APOLLONIA* (*NEOGOBIUS*) *MELANOSTOMUS*, IN LABORATORY AND IN SITU, TO VARIOUS SOURCES OF NOISE PRODUCED BY SHIPS AND HYDROLOCATION EQUIPMENT (HIDROPHONE)

Achieving the second objective of this thesis had two distinct phases:

A. Measurements (records) of the noise emissions, and their effects on the species *Mytilus galloprovincialis*

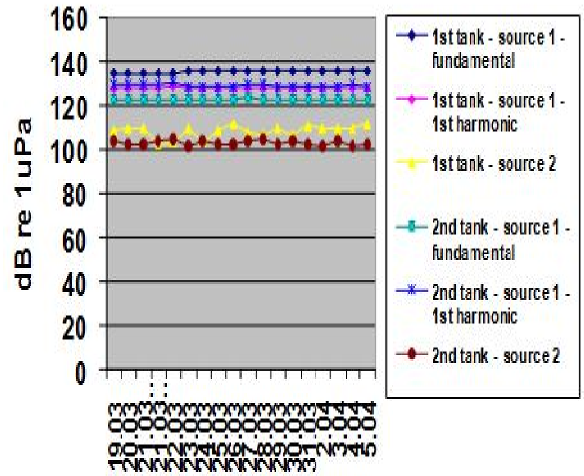
It was observed that the oxidative stress is not obvious if appropriate equipment and experimental approaches is used (experimental values for noise measurements were summarized by number of experiments, pools and sources (**Fig. 7. 1**); we found that biochemical indicators for oxidative stress (superoxide dismutase, catalase, glutathione reduced malonildialdehidă) tissues of mussels exposed to different noise emissions reveal that the action of low frequency sounds (from 300 Hz) in experimental ponds over 144 hours, does not induce oxidative stress (**Fig. 7. 2a**), increase of malonildialdehide, in case of longer exposure (216 hours) at low frequency sounds support the hypothesis of the presence of oxidative stress (**Fig. 7. 2b**).

Day	Noise level (dB re 1μPa)							
	1st tank				2nd tank			
	1st source		2nd source f = 300 Hz	SPL	1st source		2nd source f = 300 Hz	SPL
	Fundamental frequency f = 50 Hz	1st harmonic f = 100 Hz			Fundamental frequency f = 50 Hz	1st harmonic f = 100 Hz		
19.03	135	128	109	138	123	130	104	134
20.03	135	128	110	138	123	130	103	134
21.03 – 1	135	128	110	138	123	130	103	134
21.03 – 2	135	128	103	138	123	130	104	134
22.03	135	129	104	138	123	131	105	135
23.03	136	128	110	138	123	129	102	133
24.03	136	128	104	138	123	129	104	133
25.03	136	128	109	138	123	129	103	133
26.03	136	128	112	138	123	129	103	133
27.03	136	128	108	138	124	130	104	134
28.03	136	128	107	138	123	130	105	134
29.03	136	128	110	138	123	129	103	134
30.03	136	128	107	138	123	129	104	133
31.03	136	128	111	138	123	129	103	133
2.04	136	128	110	138	123	129	102	133
3.04	136	128	110	138	123	129	104	133
4.04	136	128	110	138	123	130	102	134
5.04	136	128	112	138	123	129	103	133

a

Day	Noise level (dB re 1μPa)							
	3rd tank				4th tank			
	1st source		2nd source f = 16 kHz	SPL	1st source		2nd source f = 16 kHz	SPL
	Fundamental frequency f = 50 Hz	1st harmonic f = 100 Hz			Fundamental frequency f = 50 Hz	1st harmonic f = 100 Hz		
13.04	135	126	150	151	122	128	152	152
14.04	135	128	169	170	123	131	171	172
15.04	135	128	170	170	123	130	173	173
16.04	135	127	170	170	123	129	172	170
17.04	135	127	169	170	123	129	171	171
18.04	135	127	168	169	123	129	171	172
19.04	135	127	168	169	122	128	172	172
20.04	135	128	169	169	123	130	171	171
22.04	135	127	169	169	122	129	171	172

b



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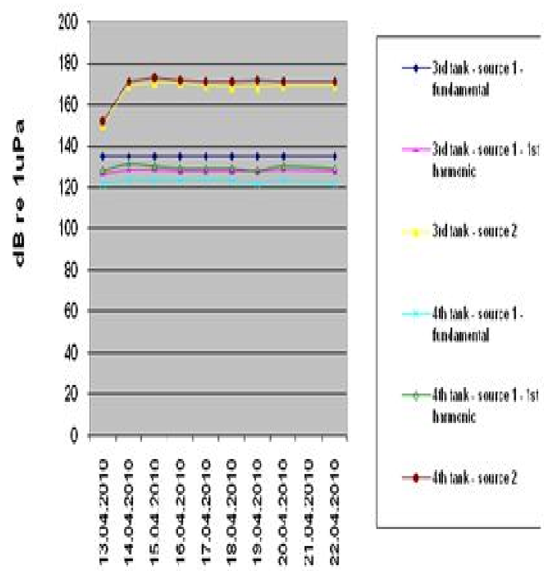


d

Fig. 7. **1 - Measured values of noise and graphic representation of its evolution in the two experiments**: a **- measured values of noise in the first experiment**, **b - values of noise levels for experiment no. 2, c - graphical representation of the evolution of noise for the first experiment**, **d - graphical representation of noise evolution for experiment no 2.**

Experimental group	Statistics index	SOD	CAT	GSH	MDA
		EU ·mg of proteins^{-1}		ng· mg of proteins^{-1}	nmol· mg of proteins^{-1}
laboratory control group	X±ES	4.54 ± 2.93	1.04 ± 0.63	1.10 ± 0.28	2.59 ± 0.92
	n	9	9	10	10
	t	-	2.54	9.68	5.33
	p	NS	0.02	0.001	0.001
	+/-M%	*+12.09*	*+ 116.66*	*-141.81*	*+172.63*
experimental group 1	X±ES	5.80 ± 3.00	1.47 ± 1.09	2.91 ± 0.12	1.61 ± 0.31
	n	10	8	9	9
	t	-	-	2.06	3.16
	p	NS	NS	0.03	0.001
	+/-M%	*+27.75*	*+41.34*	*+164.54*	*60.86*
experimental group 2	X±ES	2.82 ± 1.06	0.63 ± 0.30	1.17 ± 0.42	2.12 ± 0.84
	n	9	10	9	9
	t	2.29	-	-	-
	p	0.03	NS	NS	NS
	+/-M%	*-60.99*	*-65.07*	*+6.36*	*-22.16*

Experimental group	Statistics index	SOD	CAT	GSH	MDA
		EU· mg of proteins^{-1}		ng· mg of proteins^{-1}	nmol · mg of proteins^{-1}
laboratory control group	X±ES	7.81 ± 2.54	1.41 ± 0.37	1.92 ± 0.30	2.03 ± 0.61
	n	10	10	10	10
	t	4.48	7.02	3.37	4.92
	p	0.001	0.001	0.003	0.001
	+/-M%	*+92.83*	*+182.00*	*-29.68*	*+113.68*
experimental group 1	X±ES	4.10 ± 1.02	0.65 ± 0.20	2.80 ± 0.80	4.61 ± 1.96
	n	10	10	9	10
	t	4.27	6.38	2.96	3.96
	p	0.001	0.001	0.001	0.001
	+/-M%	*-90.48*	*-156.36*	*-45.83*	*+127.09*
experimental group 2	X±ES	4.05 ± 1.47	0.83 ± 0.36	2.31 ± 0.46	4.65 ± 0.48
	n	10	10	10	10
	t	4.03	3.40	2.22	10.57
	p	0.001	0.003	0.03	0.001
	+/-M%	*-92.83*	*-69.87*	*+20.31*	*+129.06*

a **b**

Fig. 7. 2 – Average values of: superoxide dismutase, catalase, reduced glutathione and malonildialdehide according to:

a - 144 hours of exposure to acoustic emissions of 7 V RMS at 300 Hz, b - 216 hours of exposure to acoustic emissions of 7 V RMS at 300 Hz

During the experiments, we chose a fixed frequency for the signal generated by the hydrophones over a broadband signal in order to identify the contribution of hydrophones to SPL. For lower frequencies the oxygen injectors noise spectrum dominates the frequency spectrum, and when we have higher frequencies, teh noise of hydrophones is teh only noise source.

If mussels are exposed to 72 hour high frequency sound (starting with 16 kHz), for more than 72 hours, induction of oxidative stress is observed (**Fig. 7. 3a, Fig. 7. 3b**).

In the last 72-hour exposure to noise of 173 dB (totaling 216 hours), the mean values of biochemical parameters analyzed showed a direct involvement of cellular antioxidant defense systems against free radicals and even an inability to protect the cells (**Fig. 7. 3b**), which is a proof of the fact that medium oxidative stress appeared.

Experimental group	Statistics index	SOD	CAT	GSH	MDA
		EU *mg of proteins^{-1}		ng* mg of proteins^{-1}	nmol* mg of proteins^{-1}
laboratory control group	X±ES	4.69±1.26	0.76±0.32	0.52±0.22	0.80±0.68
	n	10	10	10	10
	t	7.46	-	9.55	-
	p	0.001	NS	0.001	NS
experimental group 3	X±ES	6.22±1.01	1.22±0.22	0.22±0.08	0.49±0.29
	n	10	10	10	10
	t	2.97	3.67	4.02	-
	p	0.008	0.001	0.001	NS
experimental group 4	X±ES	6.09±1.79	1.46±0.15	0.36±0.18	0.51±0.24
	n	10	10	10	10
	t	2	6.12	-	-
	p	0.05	0.001	NS	NS

Experimental group	Statistics index	SOD	CAT	GSH	MDA
		EU *mg of proteins^{-1}		ng* mg of proteins^{-1}	nmol* mg of proteins^{-1}
laboratory control group	X±ES	6.50±0.52	1.14±0.28	1.75±0.22	0.78±0.24
	n	10	10	10	10
	t	27.55	5.57	3.11	4.91
	p	0.001	0.001	0.005	0.001
experimental group 3	X±ES	5.56±1.07	1.07±0.27	1.93±0.45	1.12±0.50
	n	10	10	10	10
	t	2.22	-	-	-
	p	0.03	NS	NS	NS
experimental group 4	X±ES	3.86±1.98	1.10±0.43	2.04±0.33	1.43±0.20
	n	10	10	10	10
	t	4.07	-	2.30	6.52
	p	0.001	NS	0.03	0.001

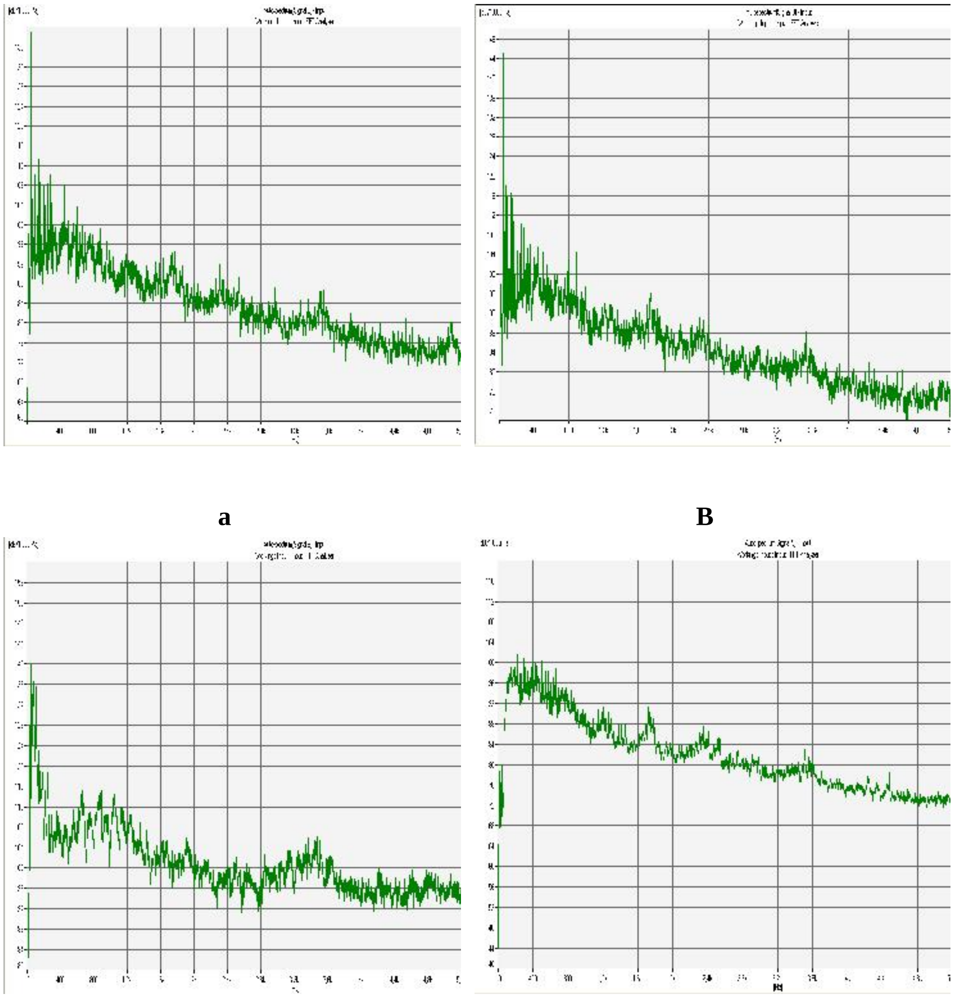
a **b**

Fig. 7. 3 – Average values of : superoxide dismutase, catalase, reduced glutathione and malonildialdehide according to:
a - 144 hours of exposure to 173 dB acoustic emissions, at 16 kHz, b - 216 hours of exposure to 173 dB acoustic emissions at 16 KHz.

b. Results and discussions on noise emissions, and their effects on *Neogobius melanostomus*

During the whole experimental period (ten days of captivity, 8th -18th October) the fish were subjected to a moderate and varied underwater noise (**Fig. 7. 4a**, **Fig. 7. 4b, Fig. 7. 4c**); the group test and control group (GC) were subjected to the surrounding noise generated by traffic in the port - see subchapter 8.1 –different records of the noise produced by ships.The levels of ambient noise seen on the spectrograms are relatively constant, between 121-123 dB re 1 Pa (**Fig. 7. 4d)**. Between 10th and 12th October the experimental groups were exposed to noise coming from the source (hydro – pneumati mechanism), at a rate of emission of sound for an hour and 2 hours break. Noise levels were in the range from 157 dB re 1 Pa 1 Pa.F to 163 dB re1 Pa.F.

Between 13th and 15th October the rate of fish exposure to vibration was modified. The ship's diesel generators were used as additional noise sources. On October 14th , after measuring the ambient noise, a diesel generator was started and operated for about 25 minutes. Then, a second diesel generator was started and recorded another 25-minute noise. After a 3 hour break, the noise source was turned on. After 10 minutes, the first generator was fed, and after another 10 minutes, the second was fed as well. With a diesel generator, the noise level was 139 dB, -145 dB, with two 145 dB diesel generators and with both the generators and with the noise source the level rose to 159 dB (**Fig. 7. 4**).



a B c D

Fig. 7. 4 the spectrogram of the measured noise: a - with a generator: 139 dB re 1 Pa b – with two generators: 145 dB re 1 Pa c - with two generators and the noise source: 159 dB re 1 Pa; d – of the surrounding underwater environment in the control group area: 121 to 123 dB re 1 Pa

In the last 48 hours, the noise source was set to generate increasing noise. Also, an underwater video camera was placed in front of the cage in the cage of experimental group no 2. Each movement of fish was recorded. The maximum levels measured ranged between 156 dB re 1 Pa to 167 dB re 1 Pa 1 Pa.

Increasing vibration intensity (157-163 dB re 1 Pa), with a steady exposure (one hour of activity mechanism hydro - pneumatic, two hours break) causes oxidative stress installation after 72 hours, shown by lower levels of superoxide dismutase, catalase, reduced glutathione, due to increased concentration of oxygen free radicals generated by stress (**Fig. 7. 5a, Figure 7. 6**) (some fish trapped in the vicinity of the source of noise died after 72 hours exposure (GE - 1).

Exposure of fish to different vibrations and high intensity (1156 dB re 1 Pa şi 167 dB re 1 Pa) for a further period of 72 hours induces severe oxidative stress values confirmed by specific biochemical indicators examined, especially malonildialdeide concentration, which show that cell lysis is also appearing (**Fig. 7. 5b, Fig. 7. 6**)

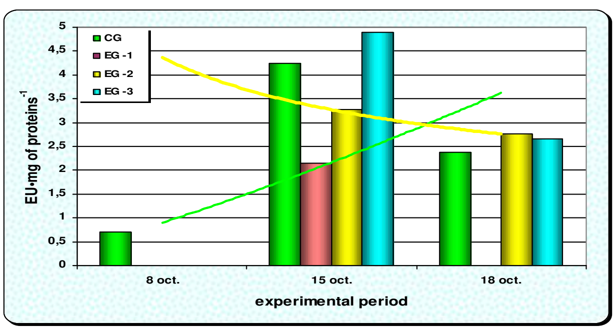
Experimental group	Statistics index	SOD	CAT	GSH	MDA
		EU ·mg of proteins⁻¹		mcg· mg of proteins⁻¹	n mol· mg of proteins⁻¹
control group (15.10.2010)	X±ES	4.25±0.17	1.66±0.12	2.25±0.15	0.48±0.05
	n	5	6	6	5
EG – 1 (15.10.2010)	X±ES	2.15±0.32	0.93±0.12	3.21±0.19	0.83±0.03
	n	6	6	6	6
	t	5.10	6.67	5.79	4.13
	p≤	0.001	0.001	0.01	0.05
	+/-M%	-56.91	-53.73	-50.69	+23.88
EG – 2 (15.10.2010)	X±ES	3.27±0.34	1.56±0.17	2.73±0.20	0.78±0.01
	n	6	6	6	6
	t	2.38	1.55	2.51	3.75
	p≤	0.05	NS(>0.05)	0.05	0.05
	+/-M%	-30.46	-22.38	-58.06	+16.41
EG – 3 (15.10.2010)	X±ES	4.79±0.20	1.78±0.18	2.62±0.28	0.80±0.05
	n	6	6	6	6
	t	1.76	2.09	3.57	8.58
	p≤	NS(>0.05)	NS(>0.05)	0.05	0.01
	+/-M%	-2.00	-11.44	-59.75	+19.40

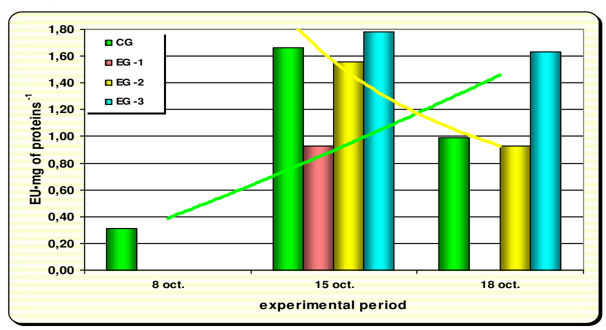
a

Experimental group	Statistics index	SOD	CAT	GSH	MDA
		EU ·mg of proteins⁻¹		mcg· mg of proteins⁻¹	n mol· mg of proteins⁻¹
control group (18.10.2010)	X±ES	2.37±0.57	0.99±0.10	1.56±0.06	1.02±0.10
	n	6	5	6	5
EG – 2 (18.10.2010)	X±ES	2.76±0.16	0.93±0.15	2.04±0.19	1.96±0.17
	n	6	6	6	5
	t	5.52	5.90	6.72	5.73
	p≤	0.01	0.001	0.001	0.01
	+/-M%	-44.68	-53.73	-68.66	+192.53
EG – 3 (18.10.2010)	X±ES	2.65±0.19	1.63±0.03	1.76±0.15	1.34±0.13
	n	6	5	6	6
	t	6.12	4.56	8.43	7.34
	p≤	0.001	0.05	0.001	0.01
	+/-M%	-46.89	-23.31	-72.96	+100.00

b

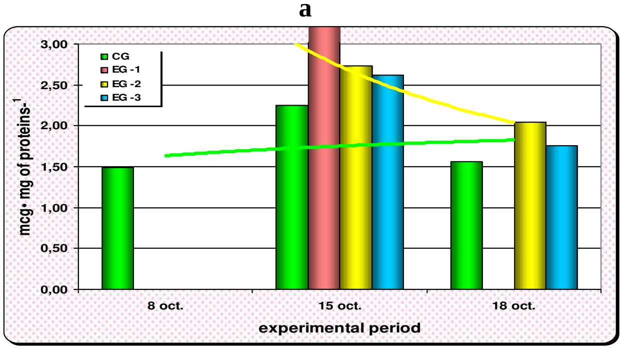
Fig. 7. 5 – Average values of : superoxide dismutase (SOD), catalase (CAT), reduced glutathione (GSH) and malonildialdeide (MDA) in liver, during the 10 day rhythmical exposure to noise[between a- 157 - 163 dB re 1 Pa for 72 hours (hydro-pneumatic mechanism] , followed by 72 hour exposure at 139/145/159 dB; b-short intervals of variable intensity noise (139 dB re 1 Pa, 145dB re 1 Pa and 159 dB re 1 Pa) during the last period of 72 hours

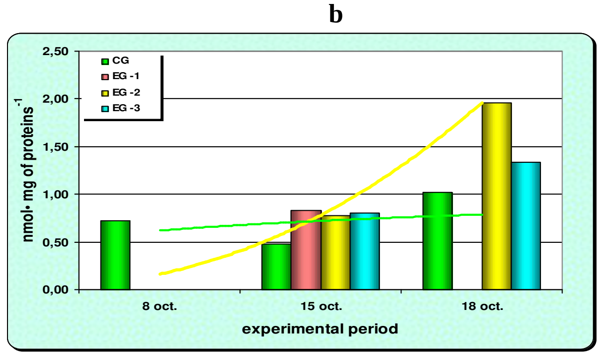




a

b





c

d

Fig. 7. 6 – Concentration dynamics of: SOD (a) , CAT (b) , GSH (c) and MDA (d) in liver tissue of the frog fishr that were exposed for 72 hours at a noise that varied between 157 and 163 dB re 1 Pa dB re 1 Pa, and in the last 72 hours at 139/145/159 dB

Up to the present date there is no audiogram for the Black Sea fish (eg Neogobius melanostomus, Gobius niger, etc.), the investigations will be unable to conduct such studies. However, there is some research on the red-mouthed fish available in field literature (*Gobius cruentatus*); this species can detect sounds between 100 and 700 Hz (100-3000 Hz frequency tested) (**Fig. 7. 7**) Wysocki et al ., (2009).

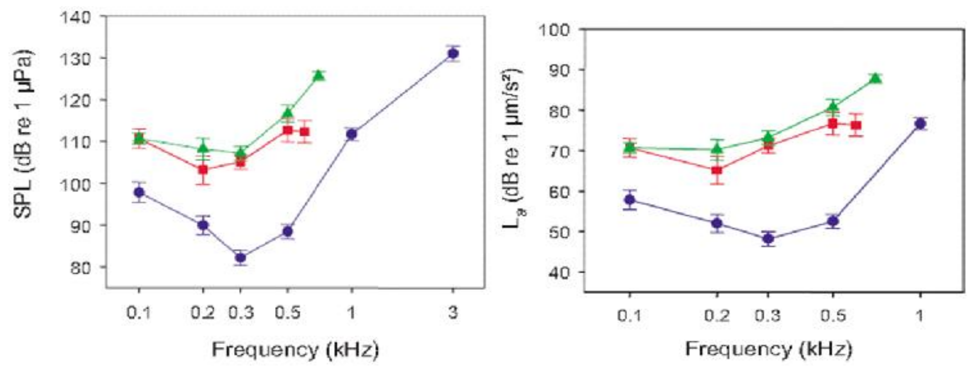


Fig. 7. 7 - Audiograms at SPLs average (a) particle acceleration (b) with the levels of thresholds of hearing for three species investigated: Gobius cruentatus – triangle; Chromis Chromis - square; Sciaena umbra –circle. according to Wysocki et al., (2009)

By adapting this audiogram to the concrete conditions of the measured parameters related to various noise sources, the spectograms recorded (**Fig. 7. 7**) in all 3 cases, that the accoustic emission intensity occurred in the frequency range 0 - 800 Hz, which coincides with the period of maximum receptivity of the *Gobius cruentatus* species taken as a reference mark. It should be noted that results from the development of experimental model reveal that the stress factor is the result of two independent sources: **captivity and noise**.

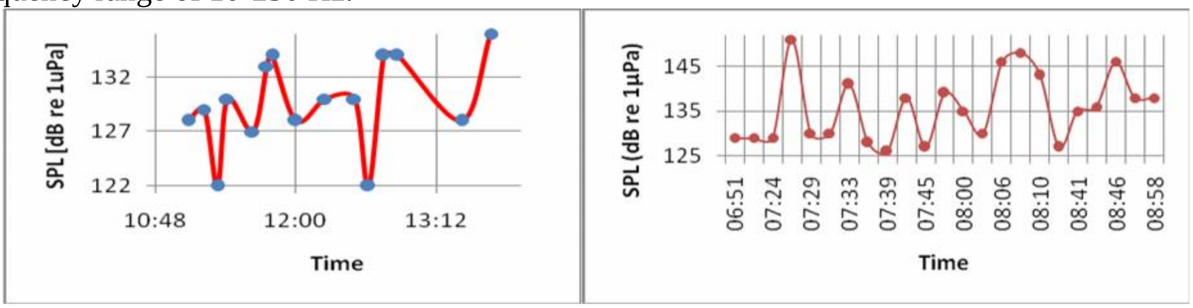
8. IDENTIFICATION OF UNDERWATER NOISE LEVEL IN THE PORT OF CONSTANTA AREA AND THE SOUNDING FEEDBACK OF THE DOLPHINS *(Sp. TURSIOPS TRUNCATUS*)

Within the 3rd objective of the paper we performed measurements and processing of signals in coastal traffic conditions, in two directions – background noise and dolphins' noise emission evaluation.

a. Evaluation of underwater noise background noise

Experiment ainmed at measuring the underwater noise produced by various types of commercial and military ships sailing in shallow waters (20-30 meters) on short to medium distances (100-500 m to 2 mm) , and the realisation of spectrograms for vessel traffic during the peak hours. Measurements were performed for 22 ships (Annexes 8.1, 8.2, 8.3).

The first series of measurements was made near the port entrance lighthouse near the "*traffic channel*", which is an interference of sounds due to waves reflected by the dam (**Fig. 5. 12** position 1, **Fig. 8 . 1a**). Earlier measurements showed ambient noise of approximately 126 dB re 1 Pa, due to high interference from the waves reflected by supporting constructions of harbor breakwater. A second series of measurements was made in the interior roadstead, apart from the interference of waves. Here the intensities of the frequency range 0-10 Hz were negligible compared to the lighthouse intensity levels of port entrance. At the first measuring point, even the smallest ship produces an increase in underwater noise of 23 dB. The highest level was 151 dB re 1 Pa (**Fig. 5. 12 position 2, Fig. 8. 1b**). The highest levels of sound intensity were recorded on frequency range of 10-250 Hz.



a **b**

Fig. 8. 1 - values determined for underwater noise measured in the North Constanta Port entrance on: a – 8th May 2010; b- 5th May.2010

Analysis of environmental noise measurements, and estimation of noise type was based on FFT diagrams (**Fig. 8. 2**), and on time - frequency techniques of analysis DWT (**Fig. 8. 3**)

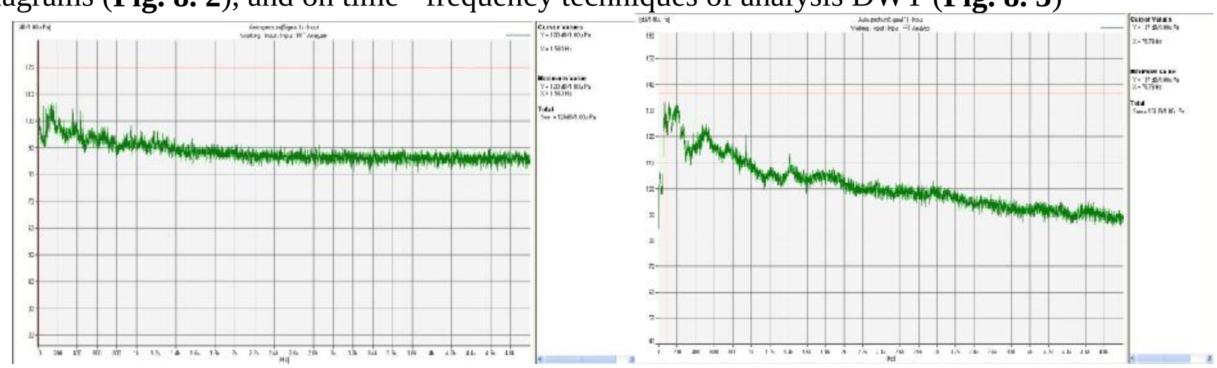


Fig. 8. 2 – FFT diagram for: a -ship Atasoylar (1.1 Nm at the entrance); ship Oana (500m from entrance), recorded at 07.36, b-ship Eltem (100 m from the entrance); ship Atasoylar (1.6 Mmat entrance) at 07.26

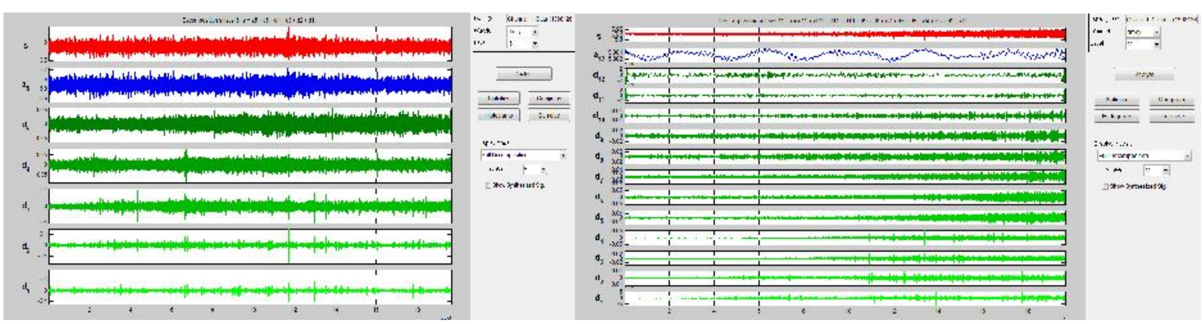


Fig. 8. 3 - DWT analysis of the acoustic signal for: a - a cargo ship – on 5 Meyer levels; b - a cargo ship – on 12 Meyer levels

Generally, in remote areas of marine traffic measurements show peaks only for sea waves. However, our measurement recorded a background noise, because of interference; the noise was measured at 8.19 and its level of intensity was l of 127 dB re 1 Pa. Peaks in the range 0-600 Hz decrease rapidly after 600 Hz , and remain constant. So it is fair to assume that **the real background noise** is lower than 100 dB re 1 Pa. This leads to the conclusion that the **background noise** is higher by about 25 dB re 1 Pa due to interference (Pricop et al., 2010, 2011).

B. Evaluation of noise emisions from dolphins (*Tursiops truncatus*)

The action took into account four major objectives:

1. Measurement of sound emissions of dolphins;
2. Differentiation / correlation of dolphin sound signals from background noise;
3. Comparative analysis of our records with the literature;
4. Evaluation of theoretical and practical ways to exploit the results obtained for the first time on the Romanian Black Sea Coast.

Some of the acoustic signals emitted by dolphins, properly recorded and processed, are highlighted as methods of analysis (Annex 8.4).

Underwater background noise does not have a constant value, and it induces different behavior on marine organisms. Using appropriate mathematical methods (Fast Fourier Transform - FFT, Discrete Wavelet Transform - DWT and Short Time Fourier Transform - STFT), we tried to classify sound signals emitted by the group of dolphins located in the northern port of Constanta (**Fig. 8. 4**) in terms of shipping traffic in the area, allowing the determination of parameters related to the functioning of teh group based based on the analysis of individual acoustic signals - sex, age, class, size and social relevance in the belonging group.

In the given case, there were a number of 200 musical notes recorded, of which a few 120 were processed (FFT diagrams, spectograms DWT and STFT). Distributions on the three classes ("tonal", "bursts in short pulses", "long pulse bursts") of the 120 distinct signals were as follows: 48 in category "tone" , and the other 72 in the categories "outbursts in short and long signals "-" short burst pulse "and" long burst pulse ". A special category was that of the combined signals, such as "burst + twitter" (Annex 8.4).

Parameters related to acoustic sign of "whistle" may vary according to age, sex and context. Young dolphins (both males and females) have higher rates of "whistling" sounds than adults, and the rate decreases more quickly with males rather than with females, as they get older (Esch et al., 2009). Adult dolphins produce more " loops" in their "whistling" than juveniles, therefore, we conclude that certain parameters are related to dolphins' level of development, their individual excitement ; hence the frequency, duration, and number of" loops" in their sounds) ;in our case the "whistle" type of sounds coming from the adults were more distinct than those from young dolphins.

Research showed that dolphins' whistles are higher in tone when a boat comes close to 1.5 km in their area (Parijs et al., 2001). In our case, the group, including the female – cub pair, showed an increase in the number of "whistles" in response to the passing boat. This evidence suggests that noise from ships transiting the dolphins arae affect group cohesion, especially for reception of high frequencies (above 10 kHz).

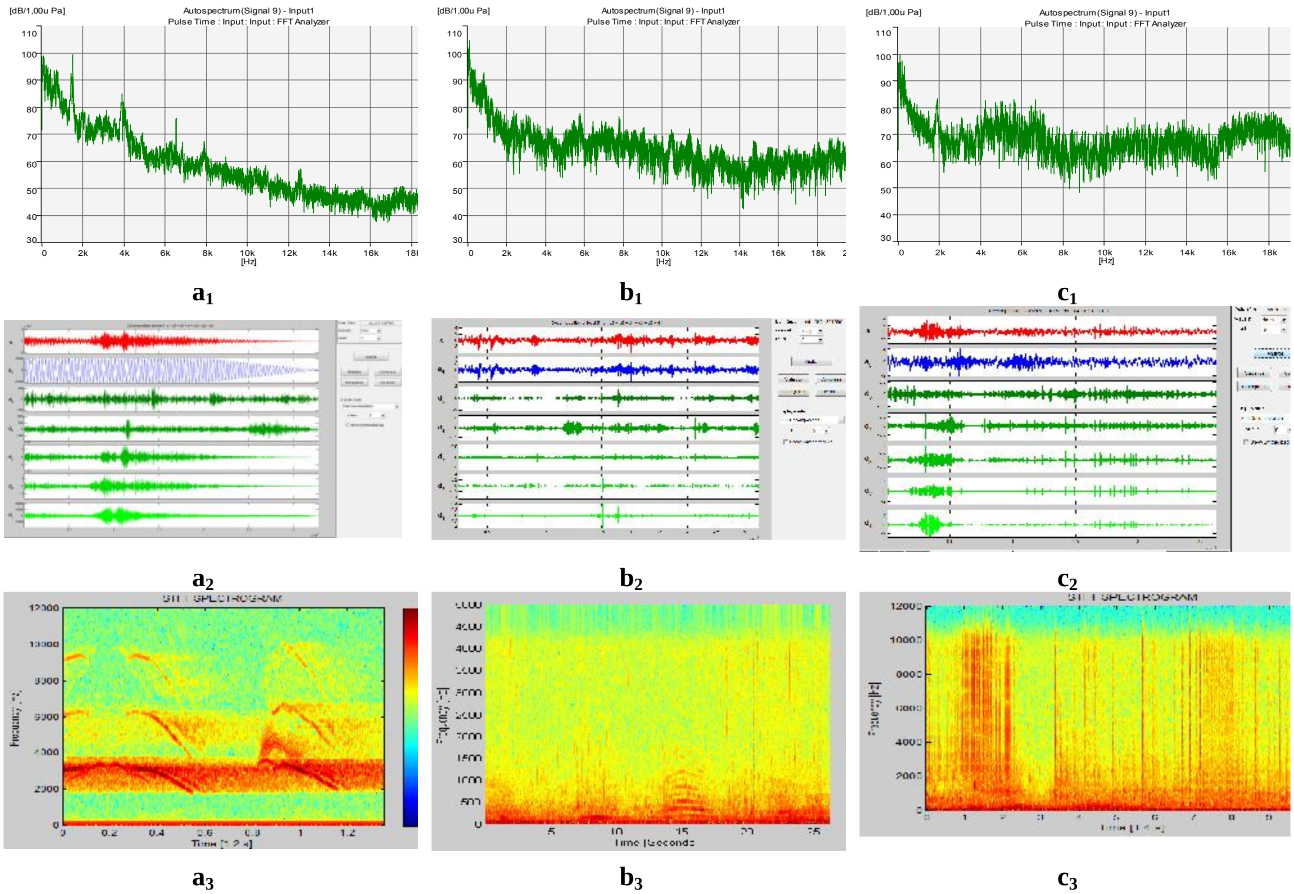


Fig. 8. 4 - Diagrams and specific spectrograms of the signals recorded for three species of dolphins *Tursiops truncatus* in the northern port of Constanta on 24th May 2010: a - the whistle category: a_1 - FFT diagram; a_2 - DWT spectrogram a_3 - STFT spectrogram; b - 'twitter' category: b_1- FFT diagram; b_2 - DWT spectrogram; b_3 - STFT spectrogram; c - "short burst pulse" category: c_1 - FFT diagram; c_2 - DWT spectrogram ; c_3 - STFT spectrogram

9. SIMULATION OF THE IMPACT OF MILITARY ACTIONS IN CONFLICTING SITUATIONS BY USING THE PROTEUSSIMULATOR, THE SIMULATOR FOR DANGEROUS CARGO, AND THE "*NAVI-TRAINER PROFESSIONAL 5000*" INTEGRATED SIMULATOR FOR SHIP STEERING

If achieving the first three objectives implied measurements, processing and interpretation of results, meeting the fourth objective was based on widespread use of simulators and related software in an integrated model designed and validated by successive simulation , according to the steps listed below:

a. Designing the model for the process - developing the conceptual model and studies on the adaptability of the model in routine situations

Starting from stage level selection of the simulation process a relational diagram on activities / military actions on coastal marine ecosystems (Gomoiu and Atodiresei, 2010) was developed, which was applied to a general case of a military base generically called ***"Matrix***

analysis of peacetime military actions effects on coastal marine ecosystems, in military bases in general. "

Expected results based on the scores obtained, revealed that waste waters, electromagnetic radiations, and noise pollution are the main categories of pollutants with high cumulative scores (40-51 out of 90 possible), and the base component evaluation indicated that naval units (military ships) training grounds and regions (including landing beaches) as well as repair shops are the most prominent components with strong potential for pollution (39-48 of 80 possible points). Based on the results obtained, this paper presents detailed steps for annihilation or limiting the effects of military peacetime activities /actions on coastal marine ecosystems.

b. Validation of the model by "waterfall simulation" of a military activity in conflicting situations with the generation of chemical pollution situations, and intervention to limit / annihilate their effects on coastal marine ecosystems

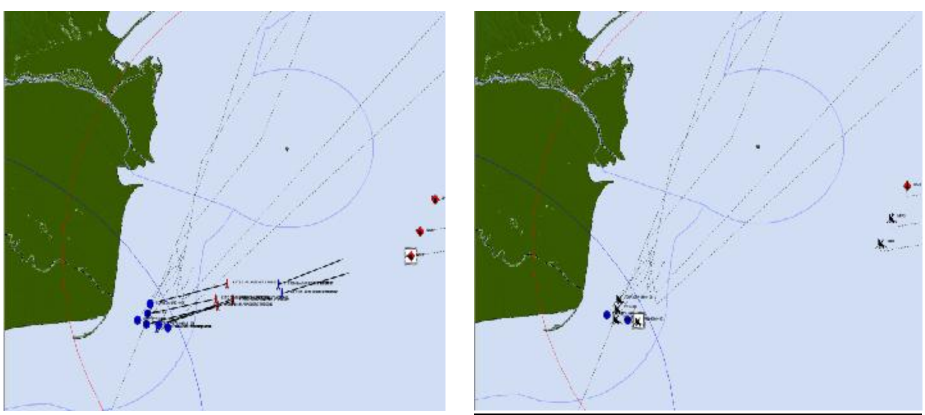
Modeling results found were:

• large-scale simulation using PROTEUS tactical simulator for a military action (Annex 9.1, **Fig. 9. 1**) generating a polluting situation;

• monitoring the spatial - temporal evolution of the pollutant, with the GNOME software installed on the simulator for dangerous cargo (Annex 9.2, **Fig. 9. 2**);

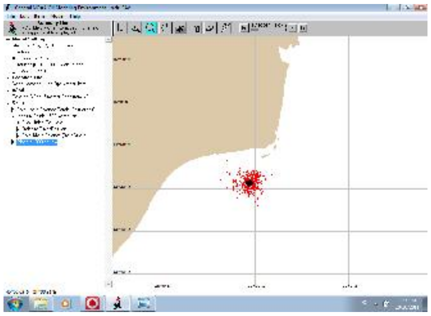
• action to limit / annihilate the effects, by choosing optimal intervention program by using the Adios software - 2 (Annexes 9.3, 9.4, 9.5, **Fig. 9. 3**);

• simulation of alternatives for intervention by: simulating environmental conditions and coastal configuration, movement of vessels, effective intervention (with skimmers and dams, by burning) (Annex 9.6, **Fig. 9. 4**).

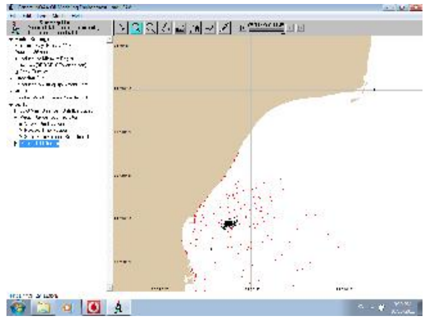


a **b**

Fig. 9.1 - Simulation of large-scale tactical PROTEUS simulator of military action to generate a situation of pollution:
a - fight employment
b -results of the combat with generation of a pollution situation

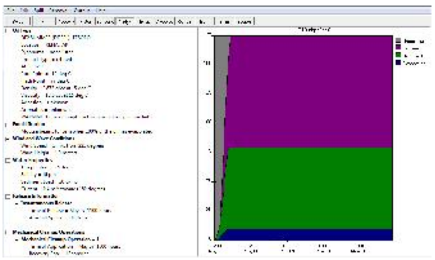


a

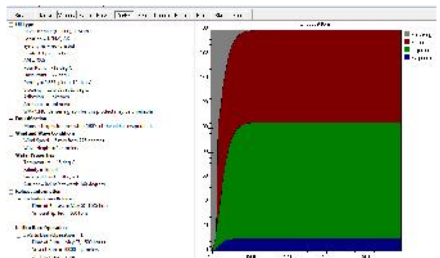


b

Fig. 9. 2 - Simulation of oil slick position with GNOME software: a - after 7hours; b - after 96 hours



a



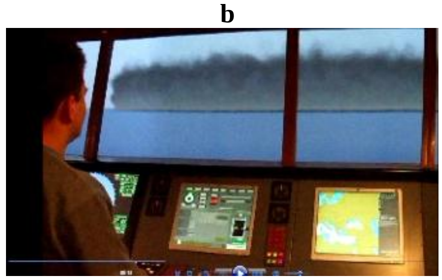
b

Fig. 9. 3 - Simulated results for choosing intervention variant: a - with skimers; b – by burning oil film

a

b

c



d

Figure 9. 4 - Simulation cases for intervention: a - coastal area, and Midia port for intyervention with skimers; b - post-conflict situation by purchasing it from Proteus simulator and oil slick marking on the map c - stain of oil collected by dams (mechanical dredging) and absorption with skimers; d - *in situ* combustion zone

According to the model the intervention to limit the effects of pollution caused by military actions, groundings, marine accidents, etc. can be successfully achieved, in real-time, and with permanent training of crews, experts,and decision makers.

10. CONCLUSIONS AND SELECTIVE RECOMMENDATIONS

Research conducted between 2004-2011 for knowing the sonorous marine environment, and the impact of military actions on marine ecosystems, measures that should be taken in order to reduce / annihilate adverse effects, as well as the case study approach - acoustic emissions in the marine environment, and their effects on coastal representative species, led me to draw some general conclusions, as follows:

1. The topic I have chosen and approached can be considered novelty in our country; it required both military technical knowledge and experience, and knowledge of biology, for the acquiring of which I needed a 7 year training period, so generously offered by the "Ovidius" University of Constanta, and by the "Mircea cel Batran "Naval Academy.

2. Of all means of warfare analysis the underwater ones possess the highest destructive potential on coastal marine ecosystems – they contain the largest amount of explosive, and can be submerged up to a depth of 350 m; the explosion produces 90% of lethal effects on marine species; once they are released they can be a constant, long term danger.

3. Concerning the lethal effects of underwater explosion on fish, estimated theoretical results for Romanian Black Sea Coast confirmed *in situ*, showed:

- BR - 6000 anti -submarine bombings did not cause mortality among pelagic species *Engraulis enchrasicholus ponticus* and *Sprattus sprattus* and no closer than 500 m confirming the 10% mortality threshold for lethal distance of 428m at a pressure in front shock wave of 211 kPa;
- for BAS – 66 anti – submarine bombings mortality was recorded among both species at distances greater than 500 m, confirming the 10% mortality threshold for a distance of 610 m with a lethal pressure shock wave front of 244 kPa;
- mortality at distances greater than 400 m were found mainly in juveniles (less mass), especially for species *Sprattus sprattus*, confirming Young ‘s statement (1991), who stated that the young will be more vulnerable than adult specimens ;
- the number of dead specimens is highly dependent on the initial spatial location of the shoal of fish (especially pelagic species) from the center of explosion, so that an accurate estimate of the total number of dead specimens, of the global biomass can be achieved only after a baseline study qualitative and quantitative composition of the experimental area;
- analysis of critical periods in terms of species vulnerability to periods of reported depth of the district, **producing explosions indicates that during April to June, less than 60 m isobath, would have negative effects on fish populations pea**k, whereas this period there were most migrations and food pairing.

4. Speaking about the impact of underwater explosion on marine mammals the following can be highlighted:

- the most manifest impact on the dolphins (*Phocena phocena*, *Dephinus delphis and Tursiops Tursiops*) will occur when the MMA - 2 mine and T-53 - VA torpedo are used;

thresholds of mortality occurr at distances of 240 - 250 m, the absolute injury at 335-350 m, and the disturbance at a distance of 2200 m;

- lowest potential impact was assessed with the use of (BR -1200, BR - 2500 and BR – 6000 reactive bombs), depending directly on the amount and nature of explosives;
- values shown, based on a single explosive charge should be taken with reserve; more than one explosives are used so that the distances calculated for the occurrence of threshold levels of impact can be "shifetd" between successive bursts; to all these tabular distance distance calculation is added.

5. Studying of the impact of underwater sound / noise submarines on a few the Black Sea populations led us to introduce the experimental method in the working protocol; the mussels (*Mytilus galloprovincialis*) experimentally exposed to different noise emission, according to analysis carried out on tissues, persented changes of biochemical indicators for oxidative stress (superoxide dismutase, catalase, reduced glutathione and malonildialdehida), from which we can draw the following conclusions:

- action of low frequency sounds (from 300 Hz) for 144 hours do not induce oxidative stress;
- increase of malonildialdeide concentration , for a higher exposure (216 hours) to low frequency sounds, explains the oxidative stress hypothesis;
- mussels exposure to high frequency sound (16 kHz), over 72 hours, induces oxidative stress.

6. As a result of exposure of an experimental fish group - *Apollonia (Neogobius) melanostomus* to diferent noise sources, in the port of Constanţa, biochemical test results performed on liver tissue led us to the following conclusions:

- ambient noise in the port of Constanta, which ranged between 121 and 123 dB re 1 Pa has mostly adverse effects on fish kept under captivity (only the malonildialdeide concentration remains constant);
- increasing vibration intensity (157-163 dB re 1 Pa), with a steady exposure rhythm causes oxidative stress installation after 72 hours, as evidenced by decreased levels of superoxide dismutase, catalase, reduced glutathione, due to increased concentration of free radicals of oxygen generated by stress; fish placed in the vicinity of the source of noise died after 72 hours exposure (GE - 1).;
- fish exposure to high intensity and varied vibrations (156 ***dB re 1 Pa*** şi 167 ***dB re 1 Pa***) for another period of 72 hours, induces severe oxidative stress values confirmed by biochemical indicators, particularly malonildialdeide concentration that reveals ocurance of cell lysis.

Based on these findings we believe that in the Black Sea shallow waters the high intensity noise / vibrations, and long exposure to them are harmful for frog fish, and we could predict, even for the ecosystem; but have to consider that factor generating stress is the result two independent sources **- captivity and noise**.

7. The analysis of sound signals emitted by dolphins in marine traffic conditions allows formulating the following conclusions:

- **background noise** does not have a constant value, showing oscillations which can reach 40-50 decibels which automatically induce different behavior of marine organisms, not necessarily mammals; therefore it necessary to mesure the noise level accurately and in advance;
- **background noise** influences the dolphins' sound emissions; measurement and signal processing have led to the finding that the "whistle" type signal can occur when the mother calls its cub, in potential threats, signaled by sudden level of noise);
- classification of audio signals emitted by dolphins located in Constanta North Port Area, in terms of marine traffic in the area, using the Fast Fourier Transform (FFT), Discrete Wavelet Transform (DWT), and Fourier transform for short periods (Short-Time Fourier Transform STFT) is an appropriate technique for the determination of parameters related to the structure and functionality of dolphin flock (sex, age, size), differential analysis technique based on acoustic signals.

8. Modeling of the effects of the anvy actions on environment was made in a new concept,by the integration and use of the existing simulators in a 'waterfall" configuration, which meets the optimal time to obtain final decision in the chain of events: military action → → → → generating pollution situation→ → hydro-meteorological information received for the respective district → → → → dispersion modeling of pollutants, intervention for limiting the spill, for hydrocarbon pollution. Using the proposed model provides the optimal solution and decision-making in about 20-30 minutes after submittal of military action result, choosing way to intervene: use of antipollution dams by the help of skimmers, use of dispersing systems, or use of burning of pollutants.

RECOMMENDATIONS:

In order to ensure proper management of coastal marine environment based on getting better knowledge of underwater sound system, and considering the results obtained during the development of this thesis we consider appropriate to make the following recommendations:

- the introduction of the marine monitoring programs on the Romanian Black Sea Coast of actions observations and measurements of underwater noise on marine and freshwater;
- create underwater noise charts of the Romanian Black Sea coast in marine and river zones general, and, at least, in the main ports, tourist resorts and major waterways of the Danube Delta Biosphere Reserve, implicitly maritime Danube, in particular;
- comparing the noise charts with the charts showing the main migration routes of fish with commercial value;
- analyzing the reproductive rates of fish in conjunction with accoustic sensitivity of the species (audiograms);
- limiting the areas of fast sports boats action on the isobath and annual periods, in order to maintain normal conditions of migration for reproduction and / or feeding of various species of fish (*Psetta maeotica*, *Huso huso, Acipenser stellatus, Alosa Pontica*, etc.;

- continuation of research on dolphins' emission of sounds by:
    - activities related to the ethology of species (feeding, playing, exploring the marine environment, communication, etc..) Wavelet techniques development in strictly delineated areas (pools, aquariums, etc.);
    - creation of databases related to appropriate types of signals (acoustic prints) ;
    - using the potential of acoustic techniques to diagnose sick dolphins.
- Determining the level of noise emitted by point sources or network sources (hydraulic structures, subsea wells, the military applications – different prints of underwater accoustic explosions, military sonars (data were recorded, but unfortunately they can not be mentioned in this paper, as acoustic prints om military ships are classified)
- Upgrading and use of the model based on the simulators existing in the Navy at present, to ensure effective interventions in emergency situations, in cooperation with the border police, The Romanian Naval Authority, etc. Prefecture, etc..

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